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R E M A R K S
O N T H E
R E P O R T
O F

Mr. JOHN GOLBORNE,
ENGINEER,

Dated DECEMBER 2d, 1777,

ON A VIEW TAKEN IN PURSUANCE OF
AN ORDER OF THE

Bedford Level Corporation.

[Price TWO SHILLINGS.]

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LETTERS addressed to the AUTHOR, to be left at Mr. Goddard's, Merchant, Carlisle-street, Soho, will be duly answered.

B. J. 1. 201*

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R E M A R K S
O N T H E
R E P O R T
O F

Mr. JOHN GOLBORNE,
E N G I N E E R,

Dated D E C E M B E R 2d, 1777,

O N A V I E W T A K E N I N P U R S U A N C E O F
A N O R D E R O F T H E

Bedford Level Corporation,

I n t h e M o n t h s o f J U N E a n d J U L Y l a s t,

O F T H E

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By W I L L I A M E L S T O B B ,
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a n d S . L E A C R O F T , C h a r i n g - C r o s s , L O N D O N .

M, DCC, LXXVIII.

E R R A T A.

Page 4, line	29,	<i>For Clay hill, read Clay hith.</i>
10, l. 26,	27,	<i>Read I shall have occasion.</i>
11, l.	20,	<i>For five feet five inches read four feet five inches.</i>
23, l.	20,	<i>For temporally read temporarily.</i>
40, l.	8,	<i>For easily read early ; and for that the read that if the.</i>
40, l.	9,	<i>For was to read was not to.</i>
41, l.	6,	<i>For all not read at all.</i>
43, l.	23,	<i>For South levels read South level.</i>
47, l.	11,	<i>For was read were.</i>
55, l.	8,	<i>For activity read acclivity.</i>
84, l.	14,	<i>For after all read if after all.</i>
94, l.	24,	<i>For greater read great.</i>
102, l.	9,	<i>For six thousand read twenty-six thousand.</i>





REMARKS, &c.

MR. GOLBORNE, in his *report*, having publickly advanced a positive charge of *error*, in the *levels* and *section* of the river *Ouse*, taken by me in 1776, for the *honourable corporation* of *Bedford level*, it makes it necessary, before I enter upon a general *examination*, to lay before the *public* such a collection of *facts*, as may enable them to judge, of the justice, or injustice of that *imputation*.

And in order to elucidate that matter, it is requisite to give the following short introductory narrative.

In the summer of the year 1767, I was employed by the *commissioners* of that district of the *great level* of the *fens*, called the *North Level*, to take a line of *levels*, along the *river Nene*, from *Peterborough bridge*, through *Wisbeach*, down to the *outfall* of that channel, to a certain *road* or place at *sea* called the *Eye*, in order to determine the *fall* of the water through that river, and to discover what obstructions lay in the bottom of the channel to hinder its *free descent* from the *Upland country* through that *level* down to the *sea*. And from the levels which were then taken I formed a *sectional drawing*, upon paper, of the surface of the water, and of the *bottom* of that river

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and channel, compared as a standard, with the height of the water in the river at *Peterborough bridge*, which at that time was *four feet, four inches*, below the top of a *wharf* near the *bridge*; this drawing I called a *longitudinal section* of that *river* and *channel*, and it was laid down by two different *scales*; the one exhibiting the distances of places in *miles, furlongs* and *poles*, and the other the inclination, fall, and depths of the water, at the several places noted in the section, in *feet* and *inches*, according to the measures taken in the course of the *levels*. By which means all the inequalities in the *bottom* of the *river* and *channel* were made conspicuous, and brought into view; but magnified in degree, according to the different proportions of the two different scales; such a drawing upon this and other like occasions I call a *longitudinal section* of a river or channel for which it is drawn.

After the taking of the levels before-mentioned, *viz.* in the year 1772, I was employed by the said *commissioners*, to take the levels from a place called *Guybirn*, about five miles above *Wisbeach*, on the river *Nene*, to a place called *Knight's Gool*, the principal outlet for the waters of *Marsh-land*, into the river *Ouse*, about five miles and an half above *Lynn*; which levels were twice taken, in two different directions, in order to examine their *accuracy*; the first line was taken from *Knight's Gool* up to a place called *Lord's Bridge*, and from thence in as strait a line as was practicable, over the
lands

lands and a large common in *Marsh-land*, called the *Smeath*, up to *Guybirn*; the second line was brought down from *Guybirn* along the course of the river *Nene* to *Wisbeach bridge*, and from thence carried along the turnpike road leading to *Lynn*, as far as the aforesaid place called *Lord's bridge*, and from thence in the same course as at first to *Knight's goal*, from whence it was continued down to a place called the *Crutch*, at the entrance of *Lynn harbour*, about two miles below the *Town*. In the course of these levels, on a common belonging to a town called *Walpole*, between *Wisbeach* and *Lord's bridge*, I met with a place, near a *toll-bar*, from which there was an open passage down to the *Wisbeach channel*, which place I marked; and after finishing the line of levels down to *Lynn*, I returned to it, and from thence run a line of levels cross the upper part of *Wisbeach channel*, and through the marshes, as near as could be in the line in which it was proposed to make a new cut, for the benefit of *drainage* and the improvement of *Wisbeach harbour*, down to the aforesaid place called the *Eye*.

This gave me an opportunity of examining the correctness of my former levels from *Wisbeach* to *that* place; and also of comparing the *low-water marks* in *Wisbeach channel* and the outfall of the river *Nene* with the *low water marks* in the river *Ouse*, and its outfall at *Lynn*, and both with my *standard* at the *wharf* at *Peterborough*, which I was glad to obtain.

And in the same year, by another line of levels, which I was employed to take, from *Peterborough* through a navigable sluice called *Standground sluice*, placed on a branch of the river *Nene*, which runs through the towns of *March* and *Well* into the *Ouse*, through another navigable sluice, at a place called *Salter's Lode*, about a mile from *Downham bridge*, and about sixteen miles above *Lynn*, I obtained another opportunity of comparing the levels of the *Ouse* with my *standard* at the *wharf* at *Peterborough*; and as such opportunities for the comparison of the levels of different rivers are not often to be met with in the course of such business, the result will appear in its proper place.

In the years 1775 and 1776 I took the levels of the river *Ouse* by order of the *honourable corporation of Bedford level*, from a place in *Lynn channel*, called the old *Bar Beacon*, about three miles below the mouth of the *harbour*, and about five miles and a half below the *town*, up to a navigable sluice now standing in the river, about sixteen miles and three furlongs above *Lynn*, called *Denver sluice*; from which they were continued through that part of the river now distinguished by the name of the *Cambridge river*, up to a place above *Ely*, called *Clay hill*, about forty-five miles from *Lynn*; and from those levels, *longitudinal sections* were drawn in the same manner as those of the river *Nene* before described, which, with others of that river called the *New Bedford*,

or

or the *Hundred-foot*, through which the waters of the *Great Ouse* now pass, with books of particulars of those *levels*, and observations upon the state of those *rivers*, in the years before-mentioned, were transmitted to *Charles Nalson Cole*, Esq. register to the *honourable corporation of Bedford level*, at the *Fen office*, in the *Temple*, in the month of *August*, 1776.

From this narrative it is apprehended, that what *Mr. Golborne* has said upon my *sections* and *levels* in his *report*, will be generally understood.

In page 4th and 5th of *Mr. Golborne's* report, he says, " On my arrival at *Lynn*, *Mr. Elstobb's* section of the *Ouse* was shewn to me, by which it appeared there was a fall of eight feet in five miles, from the *Bar Beacon*, to the *Common Staitb*, at *Old Lynn*; and from thence to *German's Bridge*, almost seven miles, seven feet six inches fall; and from thence to *Denver sluice* nine miles and a half, five feet six inches fall; so that there is a fall of thirteen feet in sixteen miles and an half, from *Denver sluice* to *Lynn*, and adding to this the fall from *Lynn* to the *Bar Beacon*, it makes the whole, from *Denver sluice* to the *Bar Beacon* at sea, to be twenty-one feet in twenty-one miles and an half.

" In the year 1769, says *Mr. Golborne*, I was called to give my opinion of the best method for draining the *North level*; and *Mr. Smeaton's* report, with *Elstobb's* section
" of

“ of the *Nene* annexed, was put into my hand.
 “ These *levels*, corresponding with the obser-
 “ vations made by Mr. *Smeaton* on his view,
 “ are a convincing proof of their *accuracy*.
 “ By these *levels*, it appears there is a fall of
 “ eighteen feet in thirty-two miles, from a
 “ mark four feet four inches beneath the top
 “ of the wharf at *Peterborough bridge*, to the
 “ *Eye* at sea.—Now for his section of the
 “ *Ouse* it appears, that the low water-mark
 “ at *Denver sluice* is three feet *higher* than the
 “ mark on the wharf at *Peterborough bridge*;
 “ and admitting that the low water-mark at
 “ the *Bar Beacon* and the *Eye* are nearly the
 “ *same*, of which there can be no doubt, the
 “ section of the *Ouse* cannot be true for the
 “ following reasons:—On July the 16th, the
 “ surface of the river at *Peterborough bridge*
 “ was four feet eleven inches below the top
 “ of the wharf, which is seven inches lower
 “ than when Mr. *Elstobb* took his levels; and
 “ admitting the water from thence to *Stand-*
 “ *ground sluice* to be nearly stagnant, that
 “ sluice then penned one foot eight inches;
 “ *Green’s sluice* then penned one foot eight
 “ inches, and *Ashling’s sluice* below *Whittlesey*
 “ penned eleven inches; making in the whole
 “ four feet ten inches; so far we speak from
 “ facts. From thence to *Salter’s Lode sluice* is
 “ about twenty miles, and as the current is very
 “ languid in that space, we will allow but
 “ two feet fall; those added to four feet ten
 “ inches, make six feet ten inches. So much
 “ at least is the low water at *Denver sluice*
 “ lower

“ lower than Mr. *Elstobb's* mark at *Peter-*
 “ *borough bridge*. But Mr. *Elstobb's* section
 “ of the *Ouse* makes low water at *Denver*
 “ *sluice* three feet higher than his mark on
 “ the wharf at *Peterborough bridge*; whereas
 “ it is at least six feet ten inches lower; a
 “ great difference this of nine feet ten inches
 “ in the whole.

“ Therefore finding that no confidence
 “ could be placed in these levels, I applied to
 “ Mr. *Whitworth*, who levelled for that great
 “ genius Mr. *Brindly*, and who has had more
 “ experience in that branch than any man of
 “ his profession). He went and levelled from
 “ the *Crutch beacon* to *Denver sluice*, from
 “ whence there was a fall of six feet seven
 “ inches, viz. one foot fall from *Denver sluice*
 “ to *Eau brink*, being near eleven miles; and
 “ from thence to above *Lynn*, nearly in the
 “ line as formerly proposed by Mr. *Kinderly*;
 “ four feet nine inches in spring tides; which
 “ in the course of the river is six miles, but
 “ in a strait line over the lands two miles and
 “ three quarters, and from thence to the
 “ *Crutch beacon* (being three miles) ten inches
 “ fall; these levels, says Mr. *Golborne*, are
 “ again a proof of the great power of water,
 “ when acting in a confined channel, as there
 “ is but one foot fall in eleven miles.”

Mr. Golborne says, by my section of the *Ouse*
 it appears, that the low water mark at *Denver*
sluice is three feet higher than my mark on the
 wharf at *Peterborough bridge*.

But

But how does this appear? My section and levels of the *Ouse* have of themselves no more immediate connection with the wharf at *Peterborough bridge* than they have with the *Tower wharf* in the river *Thames*; and without some *medium*, some intermediate *line of levels*, they may be as well compared with the *one* as the *other*; and Mr. *Golborne* might with as much reason have asserted, that by my section of the *Ouse* it appeared, that the low-water mark at *Denver sluice* is three feet higher than the bottom stair at *Tower wharf*, as that it appears to be three feet higher than the mark on the wharf at *Peterborough bridge*; without some *medium*, some intermediate *line of levels*, they cannot be compared. And the only thing of that sort which Mr. *Golborne* has produced, is the levels from *Peterborough bridge* to *Salter's lode*, founded partly upon experiment and partly upon *conjecture*; and what is very remarkable, is, that by the conclusion which he, himself, draws from them, it appears, that the low-water mark at *Denver sluice* in my section of the *Ouse* is at least six feet ten inches lower than my mark on the wharf at *Peterborough bridge*; for the above-mentioned levels are the only *medium* by which Mr. *Golborne* has compared them, founded upon the least degree of facts. And yet contrary to his own conclusions drawn from them, he positively asserts that my section of the *Ouse* makes the low-water mark at *Denver sluice* three feet higher than my mark on the wharf at *Peterborough*

borough bridge, which he says makes a difference of nine feet ten inches in the whole.

But what is this *difference*, and what is his *assertion* founded upon? Why, upon Mr. *Golborne's* own *presumption*, not grounded upon any *fact* at all; it is upon the presumption that the low water-mark at the *Bar beacon* and at the *Eye* are nearly the *same*, of which he says there can be no doubt; and if so, then my section of the *Ouse* cannot be true; but this is a matter so far from being out of doubt, that I absolutely deny it, and as Mr. *Golborne* has not attempted the least shadow of a *proof*, all his conclusions drawn from it entirely fall to the *ground*; and without some *medium* of comparison he might as well conclude, that the low-water mark at the *Bar beacon* was nearly the same at the *buoy of the Nore*, as at the *Eye*. And that the low water-mark at the *Bar beacon* is not equal to that at the *Eye* may reasonably be supposed, from Mr. *Golborne's* own conclusions, and the levels he mentions to have been taken from the *Crutch* to *Denver sluice*; for by his own conclusions he makes the low water mark at *Denver sluice* to be six feet ten inches lower than my mark at the wharf at *Peterborough bridge*, and by the levels he makes the fall from *Denver sluice* to the *Crutch* to be six feet seven inches; consequently he makes the low water-mark at the *Crutch* thirteen feet five inches lower than my mark at *Peterborough*, and he allows that the low water-mark at the *Eye* is eighteen feet

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lower

lower than the same mark; therefore the low water-mark at the *Crutch*, according to Mr. *Golborne*, must be four feet seven inches *higher* than the low water-mark at the *Eye*. The distance from the *Crutch* to the *Bar beacon* is about three miles, nearly the same as between the place Mr. *Golborne* mentions above *Lynn* and the *Crutch*, in which he says there is a fall of ten inches only; if therefore the fall from the *Crutch* to the *Bar beacon* should continue that proportion or near it, it would follow that the low water-mark at the *Bar beacon* must be about three feet *higher* than the low water-mark at the *Eye*; and therefore from Mr. *Golborne*'s own conclusions he could not with any reason infer an equality.

However, that the low water-mark at the *Bar beacon* and at the *Eye* are not nearly *equal*, but that the former is considerably *lower* than the latter, I shall shew in due course, by a *medium* of *levels* by which they were properly compared.

Mr. *Golborne* having given me credit for the *accuracy* of my *levels* taken in 1767, in the course of the river *Nene*, from *Peterborough* through *Wisbeach* to the *Eye* at *sea*, I shall have occasion to say the less about them, and shall only mention, that in that line of *levels* taken from *Guybirt* by *Wisbeach* to *Knight's gool*, in the year 1772, that place on *Walpole common* said to be *marked*, and from which a line of *levels* as before mentioned was run down to the *Eye* at *sea*, in the *Wisbeach chan-*
nel

nel, was by the levels then taken, found to be about one foot *higher* than the upper *offset* in the North *abutment* of the arch of *Wisbeach bridge*, which by the levels before taken in the year 1767, was stated to be five feet ten inches *lower* than the *coping stone* in the North-east wing of *Gunthorp sluice*; the distance of which two places according to the measures then taken was about five miles and three quarters. And the distance between *Wisbeach bridge* and the *Eye* at sea is about thirteen miles, and the low water-mark at the latter place, as marked in the section of that river, is about twelve feet seven inches lower than the upper offset of the *bridge* at the former place. By the levels taken from the aforesaid place on *Walpole common* to *Gunthorp sluice*, and down to the *Eye* at sea, it appeared, that the coping stone in the North-east wing of *Gunthorp sluice*, the same as before-mentioned, was about five feet five inches *higher* than the place marked on *Walpole common*; and consequently about five feet five inches *higher* than the offset at *Wisbeach bridge*, which makes a difference of only about *five inches* between two fixed objects, though the distance in one course was only *five miles* and *three quarters*, and in the other about *nine miles* and *three quarters*. And in the same line of *levels* the low water-mark at the *Eye* in the aforesaid *Wisbeach channel* was found to be thirteen feet four inches below the mark on *Walpole common*, and consequently about twelve feet four inches below the offset at *Wisbeach*

bridge, nearly about the same as it was stated before in my section of that river, in the year 1767. And such an agreement in two such different courses, in such different periods of time, must greatly confirm the *correctness* of the *levels* from *Wisbeach* to the *Eye*, and as there is no reason to doubt of the correctness of any other parts, and as they agree with such observations as have been made of them, they may be looked upon to be of established *accuracy*, and therefore I shall upon any occasion refer to them at *such*.

By these levels it appears, that the offset at *Wisbeach bridge* is five feet ten inches below my standard at *Peterborough*, and the coping stone in the North-east wing at *Gunthorp sluice* is very nearly upon a level with it.

The distance from *Peterborough* to *Wisbeach* is about eighteen miles and seven furlongs and the low water-mark at the *bridge* was about five feet seven inches *below* my standard at *Peterborough*; the distance from *Peterborough* to *Gunthorp sluice* is about twenty-four miles and three quarters, and the low water-mark in the main channel against that place as marked in the section, was about nine feet *below* my standard at *Peterborough*. The distance from *Peterborough* to *Sutton Wash Way*, commonly called *Cross Keys Wash*, is about twenty-six miles and five furlongs, and the low water-mark there was about twelve feet four inches *lower* than my standard at *Peterborough*. The distance from *Peterborough* to the *Eye* at sea,
is

is about thirty-two miles, and the low water-mark there was about eighteen feet two inches *lower* than my standard at the aforesaid place.

These are some of the particulars of the levels taken from *Peterborough bridge* through *Wisbeach* to the *Eye* at sea, in the year 1767, as they stand stated in the section mentioned by Mr. *Golborne* as annexed to Mr. *Smeaton's* report, put into his hands in the year 1769, and by the *medium* of the *levels* taken in the year 1772, from *Guyhirn* by *Wisbeach bridge* into the *Ouse* at *Knight's Gool*, and from thence down to *Lynn*, as has been before mentioned; those and other particulars in the *levels* of that branch of the *Nene* may be compared with the particulars of the *levels* in that part of the *Ouse* before mentioned, and their relative differences may be known.

By these levels, viz. The levels taken in the year 1772, it appeared that the coping of the *sea sluice* at *Knight's Gool*, was about nine feet and an half *higher* than the offset at *Wisbeach bridge* which, by the former levels taken in 1767, was found to be five feet ten inches *lower* than my standard at the wharf at *Peterborough bridge*; the coping at *Knight's Gool*, therefore appears to be three feet eight inches *higher* than my standard at *Peterborough*; and at that time it was found that the low water-mark in the *Ouse*, at that place was about sixteen feet two inches *lower* than that *coping*, and consequently twelve feet six inches *lower* than my standard at *Peterborough*; and six feet
eleven

eleven inches lower than the low water-mark at *Wisbeach bridge*. And by the same levels it appeared that the low water-mark at *Lynn* was about five feet six inches *lower* than the low water-mark at *Knight's Gool*, and consequently eighteen feet *lower* than my standard at *Peterborough*; nine feet *lower* than the low water-mark at *Gunthorp sluice*, about five feet eight inches *lower* than that at the *Wash way*, and only about two inches *higher* than the low water-mark at the *Eye*. And by the same *levels* it appeared, that the low water-mark at the *Crutch* below *Lynn* was about eight feet five inches lower than that at *Knight's Gool*, and consequently about twenty feet eleven inches *lower* than my standard at *Peterborough*, and two feet nine inches *lower* than the low water-mark at the *Eye*.

By my section of the *Ouse* put into Mr. *Golborne's* hands, upon his arrival at *Lynn* in the year 1776, in which he says, it appears, *that the low water-mark at Denver sluice is three feet higher than my mark on the wharf at Peterborough bridge*. It appears that the low water-mark at *Knight's Gool*, was at that time about *seventeen feet below* the aforesaid sea coping of the *sluice*, and consequently about thirteen feet four inches *lower* than my standard at *Peterborough*, and so it stands marked in that *section*, and the low water-mark at *Denver sluice* is marked about seven feet six inches *higher* than the low water-mark at *Knight's Gool*, and consequently about five feet ten inches *lower* than my standard at
Peterborough

Peterborough, and this relative situation being determined by the circumstance of the low water-mark at *Knight's Gool* by a *medium* independent of the situation or relation of the low water-mark at the *Bar Beacon*, is an irrefragable *proof* that Mr. *Golborne's assertion* however *dogmatical*, is entirely *groundless*.

And as it appears by that *section* and those *levels*, that the low water-mark at *Lynn*, was at that time about five feet eight inches lower than the low water-mark at *Knight's Gool*, it follows that the low water-mark at that *place* is about nineteen feet *lower* than my standard at *Peterborough*, and ten inches *lower* than the low water-mark at the *Eye*; which makes a difference of twelve *inches*, from the *levels* taken in 1772. And by these and the *section* before mentioned, the low water-mark at the *Crutch* is placed about nine feet seven inches *lower* than at *Knight's Gool*, and consequently twenty-two feet eleven inches *below* my standard at *Peterborough*, and four feet nine inches *lower* than at the *Eye*; which makes a difference of two *feet*, from the *levels* above-mentioned taken in the year 1772. And in the same *section* the low water-mark at the *Bar Beacon*, stands about thirteen feet nine inches below the low water-mark at *Knight's Gool*, and consequently about twenty-seven feet one inch lower than my standard at *Peterborough*, and eight feet eleven inches lower than the low water-mark at the *Eye*; which Mr. *Golborne*, without any *ground* at all, has presumed

sumed to be nearly *equal*, and has very uncan-
didly advanced a charge of error in my *levels*.
And as in that *section*, I make the fall from *Den-*
ver sluice to the *Bar Beacon* to be about twenty-
one feet four inches, if that be taken from
twenty-seven feet one inch, the remainder will
be five feet nine inches, that the low water-
mark at *Denver sluice* is *lower* than my stand-
ard at *Peterborough*, nearly equal to what it
before appeared to be.

Here it may be observed that it need be no
matter of surprise, that I have made the low
water-marks in the *Ouse* at *Lynn*, and in the
lower parts of that river *lower* than those in the
Nene and *Wisbeach channel*, as it has been long
known they *were*; and formerly the difference
was found to be much *greater* than what I now
have made it.

Mr. *Kinderly*, (in his *Present State of the*
Navigation, in page 97) speaking of a propo-
sition that was made for bringing the river
Nene from below *Wisbeach* into the *Ouse* at
Lynn says, “ the ingenious Mr. *Rowley*, who,
“ with the nicest and most accurate instru-
“ ments, took the fall in *July*, 1722, and af-
“ firmed, that there was near *seventeen feet* fall
“ from *Wisbeach* to *Lynn* across *Marshland*,”
which is near *three feet* and an *half* more than I
have made it in my section of the *Ouse*, which
Mr. *Golborne* says, was delivered to him at
Lynn; for it has been shewn before, that the
low water at *Lynn* in that *section* stands nine-
teen feet lower than my standard at *Peterbo-*
rough

rough, and from the observations of my levels of the river *Nene* in the year 1767, it appears, that the low water-mark at *Wisbeach bridge* was five feet seven inches *below* the same standard, and the difference is thirteen feet five inches, which is the fall, or the difference, of levels, between the low water-mark at *Wisbeach bridge* and at *Lynn*; and is, as has been before said, near three feet and an half *less* than what Mr. Rowley made it in 1722.

And Mr. *Badeslade*, in his *history*, page 21, says, “ that the officers of the *Adventurers* had “ proposed, wholly to desert *Wisbeach channel* “ near *Guntborp sluice*, and carry the waters “ thereof in a large canal to be made through “ *Marshland* from *Walpole* to *Lynn*, and there “ to join the waters of the river *Ouse*, &c. for, “ say they, thereby a fall of *fifteen feet three* “ *inches* will be gained from *Wisbeach river* to “ the river *Ouse* ;” which is a difference of about five feet three inches *more* than I make it; for in my section as has been observed before, the low water-mark at *Lynn* stands nineteen feet lower than my standard at *Peterborough*, and from my observations of the levels in 1767, it appears, that the low water-mark at *Guntborp sluice* was about nine feet below the said *standard*, which makes a difference of ten feet, for the fall from *Guntborp sluice* to *Lynn*, which is five feet three inches *less* than what Mr. *Badeslade* mentions.

From all which circumstances it evidently appears, that Mr. *Golborne* had no reason in the world to found a supposition of an *equality* of the low water-marks at the *Bar beacon* and the *Eye* upon, and his assertion, founded upon that supposition, must appear to be entirely groundless.

But says Mr. *Golborne*, page the 5th of his report, "Therefore, finding that no confidence could be placed in these levels (meaning my levels, in the section of the river *Ouse*, delivered to him at *Lynn*), I applied to Mr. *Whitworth* (who levelled for that great genius Mr. *Brindley*, and has had more experience in that branch than any man of his profession). He went and levelled from the *Crutch beacon* to *Denver sluice*, from whence there was a fall of six feet seven inches, the particulars of which have been before recited in my extract from Mr. *Golborne's* report"

I shall here only request that it may be observed, that the *Crutch beacon* and the *Bar beacon* are two different things, the latter being placed about three miles below the former to *sea-ward*.

I shall give Mr. *Golborne* credit for what he has been pleased to say of Mr. *Whitworth*, and as I have not the pleasure of knowing him, I have no reason to believe but that he may be a very respectable gentleman; but what is that to the present purpose? His works and mine must stand upon their own bottoms; and may be several ways compared and considered.

First,

First, in point of probability. It is generally observed, that the falls in all rivers are quicker towards their mouths, in their approach to the sea, than in their remote and more upland parts.

In the river *Nene* and *Wisbeach* river it is manifestly so; and I will venture to appeal to all persons of experience, whether it is not apprehended to be so in the river *Ouse*.

In my levels taken from *Peterborough* bridge to *Salter's lode* in the year 1772, as before-mentioned, it appeared, that there was a fall of about eight feet eight inches from *Peterborough* bridge to the low water-mark at *Salter's Lode*, in a distance of about twenty nine miles and six furlongs; and at that time the water at *Peterborough* bridge was three feet eight inches lower than the top of the wharf at that place, which is eight inches higher than my former *standard* there; which being allowed for, makes the low water-mark at *Salter's Lode* eight feet lower than that *standard*. And when Mr. *Golborne* made his observations, the water at *Peterborough* bridge was seven inches lower than my *standard*; and he computes the fall from thence to the low water-mark at *Salter's Lode* to be about six feet ten inches, which, allowing for the difference of seven inches before-mentioned, states the low water-mark at *Salter's Lode* to be seven feet five inches lower than the aforesaid *standard*, according to his computation, founded partly upon *experiment*, and partly upon *conjecture*; which makes a difference of

seven inches only, from what I make it to be by the levels.

And here it may be proper to observe, that in my section of the *Ouse* formed from the levels taken in 1776, as has been before mentioned, the low water-mark at *Denver sluice* being placed about eight inches higher than the low water-mark at *Salter's Lode*, it stands about seven feet four inches lower than my *standard* at *Peterborough*, according to this *medium* and intermediate line of levels from *Peterborough* in the *Ouse*; which nearly agrees with Mr. *Golborne's* computation, and makes a difference from what it was before determined by the *levels* taken from *Guybirt* on the *Nene* into the *Ouse* at *Knight's Gool*, of about *one foot seven inches*; arising from the relative differences in the two different lines of levels; which in such different courses is not at all to be wondered at, in a business in which there are such a multitude of observations to be made, and circumstances to be attended to, but is another proof that Mr. *Golborne's* assertion is groundless; though *mathematical exactness* is not to be expected in any mechanical *operations*, and as some latitude must be allowed in every thing of that kind, a variation of about an inch in a mile is generally supposed as little as may reasonably be admitted, from the imperfection of *instruments*, and minute incidences which may happen in two different courses, or in the operations of different *persons*.

But

But to return from this digression. The distance from *Peterborough* to *Salter's Lode* is as aforesaid, about twenty nine miles and three quarters, and the whole fall is about eight feet, which, was it uniform, would at an average rate be more than three inches in a *mile*; and in the greatest part of the way-Mr. *Golborne* observes, the current was remarkably *languid*. And in his report, page 6, he allows that the fall in the *New Bedford* or *Hundred foot* river is about nine feet in a distance of about twenty miles, which upon an average, is near five inches and a half in a mile; but from *Denver sluice*, which is twenty miles nearer the sea than the head of the *New Bedford*, in a distance of about eleven miles to *Eau Brink*; and in that part where Mr. *Golborne* has observed such surprising instances of the force of *water*, he says, the fall was found to be only one single *foot*, which is upon an average, little more than one inch in a mile. That the fall in this part of the river where such striking instances of the power of water has been observed, should be so much less than in the river above it, where the current was observed to be remarkably *languid*, seems to carry some little degree of *improbability* with it; and that so great a difference should so suddenly arise, that the fall from *Eau brink* to a place above *Lynn*, near to where the new cut proposed by Mr. *Kinderley* was to enter *Lynn haven*, should be found to be four feet nine inches in spring tides; which in the course of the river, he says, is six miles; (but
by

by the measures taken in the course of my levels I make it about five miles) and in a strait line over the lands about *two miles and three quarters*. But taking it in the largest distance of six miles by the river, the proposed average will be nine inches and an half in a mile; and that here should be found a fall of near nine times as much in proportion as there is from *Denver sluice* to *Eau brink*, and that in a place where Mr. Golborne says, the *ebb* is so weak that it looses all power of *grinding*; and in the place where he has observed such surprising effects of the power of *water*, it should be proportionably so much *less*, is, certainly something remarkable. And that this great fall so suddenly found, should be so suddenly diminished as to be reduced in the space of three miles from that place above *Lynn* to the *Crutch*, to *ten inches* in that *whole* distance is not less remarkable than *improbable*; and I will venture to appeal to the experience of all persons who have navigated these rivers, and have made any observations upon them, whether they have not always conceived and apprehended, that the fall from *Denver sluice* to *Eau Brink* was much greater in proportion, than either the falls in the *New Bedford* or the *Nene*, between *Peterborough* and *Salter's Lode*; and that the fall from above the ball at *Lynn* down to the *Crutch* was more than *ten inches*, such conclusions I am very well satisfied would be made by most, if not all persons employed in the *navigation*, who have made observations on that

that *river*, and would be thought founded up-
on *the highest probability*.

That the *falls* in the lower parts of rivers near their mouths, communicating with the *ocean*, should generally increase as they approach towards the sea is consonant to reason; the motion of all bodies descending on *inclined planes* are *accelerated*, and the lower they descend the greater velocity they acquire. And the power of water in scouring and grinding being augmented by the increase of its velocity, and in case of the tides, the impressed motion of the water, in the upper and remote parts of a river, is generally continued for some time after the impressing force is withheld; the return of the ebbs in those remote parts does not immediately follow the subsiding of the water at the mouth; for which reason the regular fall is for a while increased, and the velocity temporally augmented, by which means it acts with an additional force upon the lower parts of the channel, scours and grinds them more down in proportion than the upper parts, and so increases the falls. And the proportional difference in the falls between the upper and the lower parts of the river *Nene* and *Wisbeach channel* as they stand in my levels of that river, very well illustrates that *effect*.

The distance from *Peterborough bridge* to *Wisbeach bridge* is about eighteen miles and seven furlongs; and when the water at the former place was at my standard, of four feet four inches below the wharf, the low water-
mark

mark at the latter was five feet seven inches below it; that is, the fall from *Peterborough* to *Wisbeach* was then five feet seven inches, in the distance of eighteen miles and seven furlongs; the average of which is about three inches and an half in a *mile*.

The distance from *Wisbeach* to the *Eye* is about thirteen miles and five furlongs, and the fall is about twelve feet seven inches, which makes an average of about eleven inches to a *mile*; which is much greater in proportion than the fall from *Peterborough* to *Wisbeach*.

The distance from *Guntbörp sluice* to the *Eye* is about seven miles and three quarters, and the fall is about nine feet two inches, which makes a proportional average of about fourteen inches in a *mile*; and three inches in a *mile* greater than the proportional average fall from *Wisbeach* to that place.

And Mr. *Labelye*, in his view of the *North Level*, page 9th, says, “ By a method much
“ less liable to error than any *spirit level*, or
“ any other *instrument*, he observed the fall, or
“ difference of levels, between the low water-
“ mark against *Guntbörp sluice* and the low
“ water-mark about four miles lower, over
“ against the *Wash-way* to be very *considerable*,
“ and near as much as it is in the mouths of
“ much better *rivers*; it being certainly not
“ less than *four feet eight inches*, which is a fall
“ of *fourteen inches* in a *mile*.”

Here it may be observed, that Mr. *Labelye* has found the falls at the mouths of the better
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fort of *rivers*, more in proportion than fourteen inches in a *mile*.

In my levels of the *Ouse* I make the distance from *Denver sluice* to *Germans' bridge* to be about nine miles and three furlongs, and the fall about five feet six inches, the proportional average of which is about seven inches in a *mile*.

The distance from *Germans' bridge* in the course of the river to *Lynn* I make to be six miles and seven furlongs, and the fall seven feet nine inches; the proportional average of which is about thirteen inches and an half in a *mile*; and the whole fall from *Denver sluice* to *Lynn* I make to be about thirteen feet three inches, and the distance about sixteen miles and a quarter, making a proportional average of about ten inches in a *mile*, which is proportionally *less* by about one inch in a *mile* than the average from *Wisbeach* to the *Eye*. And the distance from *Lynn* to the *Bar Beacon* is about five miles and three furlongs, and the fall I make to be about eight feet, the proportional average of which is about seventeen inches in a *mile*, which is proportionally *more* by three inches in a *mile* than from *Guntborp sluice* to the *Eye*. The whole distance from *Denver sluice* to the *Bar Beacon* is about twenty-one miles and five furlongs, and I make the whole fall to be about twenty-one feet four inches, the proportional average of which is near twelve inches in a *mile*; which makes a

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proportional difference of about one inch in a mile *more* than from *Wisbeach* to the *Eye*.

Mr. Golborne, in his report, page 5, says, There is one foot fall from *Denver sluice* to *Eau brink*, in the distance of near eleven miles, the proportional average of which is little more than one inch in a *mile*; and from *Eau brink* to above *Lynn*, he says, the fall is four feet nine inches, and the distance by the river about six miles, the proportional average of which is about nine inches and a half in a *mile*; the distance from that place above *Lynn* to the *Crutch*, Mr. Golborne says, is three miles, and the fall ten inches, which makes the proportional average little more than three inches in a *mile*. And upon the whole Mr. Golborne says, the fall from *Denver sluice* to the *Crutch* is six feet seven inches, and the distance, according as he has stated it in the course of the river, is about twenty miles, which makes the proportional average of the fall about four inches in a *mile*; which is proportionably less by seven inches in a *mile* than the fall from *Wisbeach bridge* to the *Eye*, and which is less by near three inches in a *mile* than in the whole fall from *Peterborough bridge* to the *Eye* at sea; for the distance of those two places is about thirty-two miles, and the whole fall, according to my levels of the *Nene* is about *eighteen feet*, which makes a proportional average of near seven inches in a *mile*.

And

And here it may be observed, that in the fall from *Eau brink* to the *place* before-mentioned above *Lynn*, there appears to be some similitude of *proportion* between them and the falls before-mentioned in the river *Nene*; and indeed it is not very different from what it stands in my section of the *Ouse*; for in that section I make the fall from *Eau brink* to a place about three furlongs above *Lynn*, (which I apprehend to be near the place which Mr. *Golborne* speaks of) to be about five feet, which is only about three inches different from what he makes it. But in the extremes, from *Denver sluice* to *Eau brink*, and from the place above *Lynn* to the *Crutch*, the disparity is very remarkable; and which is most agreeable to the analogy of nature must be left to the determination of the impartial reader.

And now dropping probabilities, and attending to facts, it should be considered that the truth of all operations may be confirmed, either by the repeated trials of the operator, or by their agreement with the like works and operations of *others*.

My levels of the river *Ouse* from the *Bar beacon* up to *Denver sluice*, (which Mr. *Golborne* so peremptorily censures, and says, that no confidence could be placed in them) were taken in the latter end of the year 1775, and the spring of the year 1776; and in the months of October and November following, in the last mentioned year, I was employed by the gentlemen of *Lynn*, to re-examine the falls in the

Ouse, and the *New Bedford rivers*, from about five miles above *Denver sluice* to the *Crutch* below *Lynn*; at which time the low water-mark at *Denver sluice* was something altered, from what it was when I formerly took it; there being only about nine feet water in the *Ouse* below the *sluice*, where before, there was eleven feet; and on the threshold of the west water way in the *sluice* there was about seven feet, where before there was eight.

By these latter levels the fall from *Denver sluice* to *Knight's gool* was found to be about six feet three inches, which is about one foot three inches *less* than before, and the fall from thence to *Common Staith* at *Old Lynn* was found to be about six feet; which is about four inches *more* than it stands in my section, and makes the fall from *Denver sluice* to *Lynn* twelve feet three inches, which is about one foot *less* than it was before made, in the distance of about sixteen miles and a quarter, and at a time when the low water-mark at *Denver sluice* was about one foot *lower* than it was when the first levels were taken; and by the latter levels the fall from *Denver sluice* to the *Crutch* was stated at fourteen feet three inches, which makes a difference of two feet eleven inches in the whole from the former, as it stands in that section of the *Ouse* delivered to Mr. *Golborne*, in a distance of about eighteen miles and an half, under the different circumstance of the low water-mark at *Denver sluice* before-mentioned, which being taken into the consideration reduce it to about
one

one foot eleven inches. But according to the levels stated by Mr. *Golborne* the difference is ten feet seven inches, a remarkable *disparity*, indeed !

Here it may be observed, that though there is not a perfect agreement (as it is not reasonable to expect that there should) in my own different operations, yet the variation is so small that it cannot afford any reasonable suspicion of any great *error*; and in order to compare my own operations with those of *others* I shall observe, that Mr. *Kinderly*, in a pamphlet published in the year 1730, (about seventeen years after *Denver sluice* was blown up, which happened in 1713, and about sixteen years before it was rebuilt, which was done in the year 1746) entitled *Observations on Humphry Smith's Scheme, &c.* says, From *Salter's Lode* there is a fall to *Eau brink* of about five feet, and from thence to *Lynn* a fall of eight feet, making together about thirteen feet; which differs very little from what it stands in my section of the *Ouse*, but is six feet five inches *more* than Mr. *Golborne* makes it from *Denver sluice* to the *Crutch*, at more than two miles below *Lynn*.

From this state of facts, the *public* and those gentlemen more immediately *interested* will be enabled to judge of the justice or injustice of Mr. *Golborne's censure* and to their candid and impartial determination I shall submit it,—

And shall enter upon a general consideration of the *plan* proposed by Mr. *Golborne*, for the *effectual draining* of the *middie* and *South levels*.

This

This I shall treat with all the candour, impartiality, and freedom, which the importance of the subject requires. For notwithstanding, I am not in the least interested in the *event*, I have always looked upon the recovery of the *great level* as a most desirable thing. the effecting it as a noble acquisition.

Though I have not been called into *Scotland* to do such great works as Mr. *Golborne* has performed in the *Clyde* and *Firth*, nor been complimented with *plate* in acknowledgment of my services, yet it gives me much pleasure to hear, that the *small* work which I had the care of executing in *Wisbeach channel*, has been so advantageous, that *navigation* and *drainage* have received great *benefit* by it, and that the *north level*, which was the most drowned of the three, is now the best *drained*; besides other good effects mentioned by Mr. *Golborne*, pages the 16th and 17th of his report. For though this work is by far too diminutive to stand in competition with the great work of deepening the *Clyde*, by machines only; yet as it was done in the out *marsh* which the spring tides frequently covered, and extended through the quick and loose *sands* over which the tides generally flowed, it was not without its difficulties; and required great circumspection to prevent, as well as some judgment to remedy the many accidents that were liable to such a work, carried on in the course of the *tide-way*. And the damming up of the *old channel* which ran through the expanded beds of *loose sands*, over which

which the tides constantly flowed, and the spring tides covered to a considerable height; rising to fourteen or sixteen feet in the *channel*, spreading themselves over the marshes, which in this place they covered on the east side, to about two furlongs in breadth: and at which the *channel* and *sand* between the marshes, was about one hundred and fifty yards wide; and the sands of such a depth that no piles could reach a bottom to support them, but would have been continually scoured up, by the increased rapidity of the *tides* and *ebbs* as the passage became contracted by them. As there was reason, to apprehend, that this would have been the consequence if such a method had been attempted, it was generally looked upon as a rash undertaking, and a thing impracticable; and even by good judges, esteemed a work of great *difficulty*; and indeed in the execution, it proved no very small one; for at the beginning of the work, in making the foundation with large *chalk stones*, brought out of the *Humber*, the rapidity of the *tides* and *ebbs* were so much increased, that in a very little time, in the contiguous parts of the channel, where the greatest depth of the water was under *ten feet*, it was increased to between *twenty* and *thirty feet deep*, and as the works were raised above low water-mark, the spring tides, for some considerable course of time running over them formed a great *cataract*; which, as the work advanced, greatly increased, till the aspect was sometimes *alarming*, not only to people in
general

general, but to some good judges. An eminent engineer from *Holland*, who several times came to view the work, was ready to think the difficulties *insuperable*. But by a plan well settled in my own *mind*, accompanied with an unremitted attention and assiduity, it was accomplished to the no small surprize of most people, and without the loss of any quantity of *materials* worthy of consideration, or any interruption of the work; and without the expence of a *flaker* to keep a balance of water against the work, as had been before proposed by some others; which effect I expected from, and it would have been answered by the *flux* and *reflux* of the *tide* through the *new cut*, upon the opening of it. But that effect was prevented by extending the cut through the *sands* farther than was at first intended, and making a dam across a run or small channel, which used to bring the tide more early up to *Guntborp sluice*, at the mouth of the first intended cut; by which means the tides coming out of the *main channel* into the lower part of the *new cut*, were obliged to find a new and more round about way, and did not arrive at the land side of the work so soon as the tide coming up the old *main channel* got up to the *sea-side* of it. This difference whilst the works were raising, and before the spring tides were quite shut out of their old course, was the occasion of the *cataraets* before spoken of; and when the spring tides were entirely shut out, the tide on the *sea-side* of the work, was for a considerable time greatly fallen
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and *ebbed out* before the flood through the new cut arrived on the *land side*; so that the whole pressure of the tide lay against it. When the new cut was first opened, and the tides had a passage through *both channels*, the tides coming up through the *old channel* to the head of the *new one*, sooner than the tide which came through it arrived, it *reverted into it*, and the two tides meeting in the *new cut* and carrying much *silt* along with them, before the dam was near finished, it was greatly *silted up*, and the bottom much *raised*; but when the *old channel* was stopped, and the tides were turned entirely through the *new cut*, such a body of water as was impelled into it, meeting with so confined and *shallow a channel*, it rushed through it with such an impetuous force, and such *rapidity* that the vessels passing through it could, not be *steered*, or any way *properly managed*, but were shot through with great *celerity* in the most *random manner*, until in a little time the bottom was scoured down *much deeper* than it was *originally cut*, and the tides passed through it with less violence.

By the before-mentioned circumstances many difficulties arose, which with less attention might soon have ruined the *whole work*; and although I have not been favoured with any particular acknowledgment, those made by the public from the *effects* of the *works* are not less *acceptable*.

The attempts for the *effectual draining* of the *middle and South levels* having hitherto been so

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very *ineffectual*, and such enormous sums of money expended upon ill-advised *schemes*, adopted from pompous *names* and narrow *principles*, it is very requisite that every new plan proposed should be duly weighed, well considered, and as accurately examined as the nature of the thing will admit of, before it is carried into execution; for which reason I have taken a freedom (which I think my duty to the *public* requires) of considering the *plan* now proposed by Mr. *Golborne*.

The first things taken notice of by Mr. *Golborne* in his report, are some of the works formerly done in the original attempt for the recovery of the *South level*, speaking of which in page 1st, he says;

“ Before I proceed further, let me take a
 “ review of so much of the several works as
 “ have occurred to me in the track, which I
 “ have just mentioned, meaning in the perambulation which he made in his view of the
 “ *levels*.”

“ Sir *Cornelius Vermuyden*, a *Dutchman*, and
 “ eminent in his days for draining lands, conducted this work, (says he) and cut a new
 “ river from *Erith* to *Denver sluice*, twenty
 “ miles long, one hundred feet wide, and six
 “ deep; and a bank was formed on the East
 “ side by the earth that came out of the river;
 “ a navigable sluice was also put down
 “ in the *old channel*, and the river turned down
 “ the *new one*. Nearly parallel to this river
 “ stood *Old Bedford bank*; and the space between

" tween them was left as a receptacle for the
 " waters in time of floods, and was called the
 " *Washes*. At the lower end of this river
 " stands *Denver sluice*, through which the
 " waters of the *Grant*, the *Mildenball*, the
 " *Brandon*, and the *Stoke* rivers pass, and they
 " join the *Ouse*.—The altering the course of
 " this river, and turning it down a new chan-
 " nel, in a somewhat *higher* situation, has
 " been censured by many; yet I must vindi-
 " cate the *idea*, as founded on sound princi-
 " ples, and according to the established rules
 " of draining; though I must censure the
 " mode in which it was executed, as being
 " productive of many of the misfortunes un-
 " der which the *levels* now labour. The old
 " course of the *Ouse* was near thirty miles
 " long, through a tract of very low ground,
 " the new one is only twenty miles; and it
 " is an established maxim in draining, to
 " LEAD THE WATERS BY THEIR SHORTEST
 " COURSE TO THEIR OUTFALL. This has
 " been done by the *Ouse*, and had the river,
 " at the same time, been cut of a proper width
 " and depth, with a foreland and bank on
 " each side, with proper bridges, it would
 " have been compleat: the waters then would
 " have been discharged to sea-ward, as fast as
 " they descended; and the banks on each side
 " confining the current, it would by its
 " weight and power, have ground down a deep
 " channel."

In the description of the *New River* said to be cut by Sir *Cornelius Vermuyden*, Mr. *Golborne* is not accurate in the situation of *Denver sluice*; that *sluice* is not placed at the lower end of *that river*, as is generally known, but it is placed in the *old channel*, in a place through which the waters of the *Grant*, *Mildenball*, *Brandon*, and *Stoke*, with the *Great Ouse* united, used to pass without interruption from thence through *Lynn haven* down to sea.

And so superior was the quantity of the waters of the *Great Ouse*, that from its first uniting with those of the *Grant*, at a place called *Harrimere*, about three miles above *Ely*, the whole stream down to the outfall at *Lynn*, with the waters of *Mildenball*, *Brandon*, and *Stoke* united took its name; and by *them*, and the free and constant *influx* and *reflux* of the *tides* into and out of all those *receptacles*, the lower parts of the channel were not only worn wider, but scoured and ground *deeper*, as appears by the petition of divers towns in *Marshland*, mentioned in Sir *Clement Edmonds's* report to the Lords of the *Privy Council*, (see *Badeblade's hist.* p. 11). And the outfall at *Lynn* was so good that Sir *Clement* in the *afore-said report* says, *that below Ely it run with such a current, that it was absolutely the best sewer of all that country*, (meaning the great level of the *fens*).

The antient state of the rivers and the condition of the *levels* previous to the works of the *undertakers*, as well as their present *circumstances*

cumstances is what Mr. Golborne should have been well acquainted with, that from *experimental effects*, he might have judged of their *propriety* or *impropriety*; for notwithstanding the subtilty of speculative reasoning, Experience is certainly the best *schoolmaster*; and the little acquaintance Mr. Golborne has had with this *country*, and the transient *view* he has taken of it, gives great reason to apprehend that he may not have come to so full a knowledge of *facts* as the importance of such a subject may require; and without proper *data* no conclusions can be rightly formed.

But now let Mr. Golborne's observations and conclusions be duly considered, and their weight and efficacy be examined.

Mr. Golborne says, he must vindicate the idea of turning the waters of the Great Ouse out of their old natural deep course, down a new *shallow channel*, made in a *higher situation*, as founded on sound principles, and according to the established rules of *draining*; although, says he, I must censure the mode in which it was executed, as being productive of *many* of the *misfortunes* under which the *levels* now labour.

The misfortunes which the levels now labour under, I apprehend, are not *many*, although very *fatal*. The want of a free, expeditious, and sufficient discharge of the waters which are to be passed through them, and those which immediately fall upon them; and the want of sufficient *banks* to prevent the waters

ters that pass through from over-spreading and deluging *them*, I believe, comprehend most of the misfortunes which the *levels* now labour under.

And how the work which has been productive of any of the misfortunes, which Mr. *Golborne* mentions; and by authentic testimony it appears, that this cut has been so, can be founded upon sound principles, according to the established rules of *draining*, I must confess I am utterly at a loss to conceive. I wish to be informed whether a channel made in the *highest* or the *lowest* part of a *flat country*, would be most conducive to an effectual *drainage*; and whether a *shallow channel*, made in the *higher* part of such a country, would not be much more liable to inundate it than one made in the *lower part*: if, therefore, the *new cut*, which Mr. *Golborne* mentions, had been made for the purpose of *draining*, it must have been a very absurd performance; but to do justice to the *Engineer*, it was not designed for any such purpose; it was intended to make a passage for the waters of the *Great Ouse* down to the sea, between the South and middle levels, without coming into either of them. So far it was rational, had no pernicious consequences attended it, and if all the upland waters had been prevented from coming into the *Fens*, it must have contributed much to their *security*; but as that has not been done, and it is apprehended it is impracticable, such remedies must be provided as the present circumstances of the *levels*

levels require ; for in every plan proposed for their recovery and security, all circumstances should be taken into consideration ; which does not appear to have been done in the making of that *new river*, nor did it fully correspond with the *maxim* Mr. Golborne lays down as an *established rule in draining* ; for by THE WATERS, in that *maxim*, is meant *all the waters* which were any way subject to annoy the *lands*, or that wanted to be discharged from *them* ; but in the case before-mentioned there was provision made for only a PART OF THEM, and that contrived without considering how the other waters left to pass through and to be brought off the *South level* might be affected by it. For as that cut was made upon the *higher ground*, if, when the water was raised against the *bank* on the East side, a breach had happened in it, the water must of necessity have spread over the land in the *South level*, toward the old channel of the *Ouse* ; especially if that circumstance which some mention be true, *viz.* that there is a natural fall of the lands towards that river, of about six inches per mile, (see *Badeslade's hist.* p. 18). Had all these circumstances been considered, it might easily have been foreseen, that the waters of the Great *Ouse*, in the time of land floods so superior in quantity to those in the other rivers, and coming through a shorter passage (notwithstanding their improper spreading over the wide washes) must needs fill the channel they run into *below*, much sooner than those waters left

to

to pass through the *South level* could come at it; and from the natural property of *fluids*, their parts being *equally pressed in all directions*, the waters being raised to an height superior to the water in the *old channel* above that place, some part of the water brought down by the *new channel* must naturally revert into it; and this effect was so *easily discovered*, that the original design of putting down: *Denver sluice* was to *prevent* it; it so happened that in about two years after the making of that *new cut*, viz. in the year 1653, St. *John's eau* was obliged to be cut to remedy the ill effects of the water above the sluice being *stopped* in, by the waters of the *Ouse* descending through the *New Bedford* river and pressing against the *sluice doors*, by its endeavouring to *revert*, as it naturally would have done, and keeping them shut until the abating of the waters towards a termination of a *land flood*, or by the accumulation of the water in the *South level*, it was raised so high as to counter-balance that in the *Ouse*; by which stoppage, that *level* was longer annoyed and inundated than it had been before *these works* were *begun*; nor was it much relieved by the cutting of St. *John's Eau*, as may be understood by *Badeslade's history*. Surely, those very *early* consequences arising from the common course of things more than a hundred years since, Mr. *Golborne* will not impute to the effect of a *bank of sand*, which he has now discovered to lie in the lower part of the channel between *Germans* and *Lynn*; nor

is it possible that could be the cause of keeping the *fluice doors shut*, in the time of land floods *only*; for that stoppage being always there, the doors must be either *always* kept shut by it when the waters were low in the river above it, or not *all not*; as all the water raised above it in the time of *land floods* must have been carried *over* it, therefore could not contribute any thing to that *effect*. When the water in the rivers above was the *lowest*, if that was the *cause*, its effect must then be the most *powerful*, and at such times the doors would have been continually kept shut, contrary to all experience and fact.

It is very evident that shortening the course of the waters of the *Ouse*, which Mr. *Golborne* so highly *approves*, was one great cause of the *misfortunes* under which the *South level* now labours.

But, says Mr. *Golborne*, had the river at the same time, been cut of a proper width and depth, with a foreland and bank on each side, with proper bridges, it would have been *compleat*.—Compleat for what? Not for the *drainage* of either of the *levels*; for very little of the waters of those levels come into it, nor was it designed for that purpose.

That it would have been more compleat for the bringing down the waters of the *Great Ouse* in the time of *land floods*, in a more safe and proper manner, and would have prevented them spreading over the wide *washes*, so *injudiciously* provided for their reception, as also have

screened the waters from the force of the *winds*, and those violent *agitations* with which it was impelled and dashed against the *banks*; and that river once made deep might have been so preserved and improved, that the *levels* would have been better *secured*, that the many ruinous and destructive breaches which have been made in the *banks* on both sides of the *washes* might have been prevented, and the greatest part of the expence of £15,000, which has been expended in the last twenty years on the *Bedford* bank might have been saved, may be very *rationaly* concluded. But all this would have contributed very little to the drainage of the *South level*; the waters left to make their passage through that, *viz.* the waters of the *Grant*, *Mildenball*, *Brandon*, and *Stoke*, with all the other small *lodes* and *drains*, are the waters which now annoy that *level*, which for want of proper *banks*, *deep* and *large* rivers, and *open* and *free passages*, *overspread* and *inundate* it.

These are the misfortunes that *level* now labours under, and the *evils* conspicuously point out the *remedies*, The *imbanking* and *deepening* the *rivers*, and the removing all *dams* and *stoppages*, and making a *free passage* for the *waters*. It is therefore not a little remarkable, that Mr. *Golborne* should be so exact in his observations and so copious in his enumeration of the bad effects of the contracted dimensions of *Sutton* and *Mepal bridges*, placed on a river which was formed on purpose to be *overflowed*, that the water might be spread over the *washes*. That he should

should overlook or pass it by, as a matter not worthy of attention, that *Denver sluice* was originally set across a river of *one hundred and fifty feet* wide, the bottom of which was fourteen feet under *soil*, and where the waters of all the rivers in the *south level* unitedly passed, and was constructed with three water-ways of only *fifty four feet clear* in the whole, and founded on a *dam* raised across the river of *eight feet in height* for that purpose. (See *Badeslade's* hist. page 68). It is indeed very possible that as *Mr. Golborne* came a stranger to the country, and had so short a time to be acquainted with the *historical facts* relating to it, this might be a matter he had not been apprized of; for surely if he had, he must have been much more struck, with its effects, than he was with the effect of the bridges in his observations of the *New Bedford*, which occasioned the waters there to expand over the *washes*, and form a lake of half a mile wide, and seventeen miles long. If so, what *less* than the inundating and drowning of the whole *south levels* in the time of *land floods*, must he have concluded to follow from such obstructions and contraction in the passage of the water through *Denver sluice*, as before mentioned. This was one of the works which *Mr. Golborne* will undertake to vindicate the idea of, and which he says was founded upon sound principles.

This was the *sluice*, the doors of which *Mr. Badeslade* has *proved*, were kept shut for several days together, by the waters of the *New Bedford*

Bedford river, of which, Mr. *Golborne* exclaims and says the *poor sluice* was in no fault. The evil lay in the wide and shallow channel between *Germans* and *Lynn* , which I have shewn could not possibly be the case. And besides, before *Denver sluice* was erected, and the new *Bedford* river was cut, if Sir *Clement Edmonds's* report and many other testimonies are to be credited, (of which I apprehend Mr. *Golborne* will not admit the least doubt) there never was any such thing as a *wide* and *shallow* channel between *Germans* and *Lynn* . At that time the channel was *wide* and *deep*, so deep that great *barges* and *keels* used to pass between *Lynn* and *Salters' Lode* at *low water*; and *Lynn haven* though 200 yards wide, was then so *deep* that the bottom of the *channel* was above thirty feet under soil. (See *Badeslade's* history, pages 62 and 104).

Here it may be observed, that there is no such necessary connection between *wide* and *shallow* channels, and *narrow* and *deep* channels as Mr. *Golborne* seems to suppose. *Wide channels* may be made and preserved *deep* by a great quantity of water passing with great velocity through them, and by an increase of quantity they may be enlarged and improved both in *breadth* and *depth*, as appears to have been the case with the *Ouse* for the space of near four hundred years, from the time of king *Edward I.* 1292, to the time of the cutting the *new Bedford* river, and setting down the *Hermitage* and *Denver sluices*, in the years 1650 and 1651. On

On the other hand, *narrow* channels having small quantities of water passing through them with very small velocity, will be apt to choak and become *shallow*, by the fullage and soil brought into them, without a sufficient force of water to drive it through them, as has been the case with that very part of the *channel* where Mr. *Golborne* received such extatic pleasure, from observing the wonderful effects which a narrow channel has of increasing the power of water, (as he seems to think) without making any considerable addition to its velocity. The proof he gives of the great power of water, when acting in a confined channel, he remarks to have been in a place where there was (according to his account) but *one foot fall* in *eleven miles*, which implies, that he supposes, the power of the water was not derived from any increase of velocity, but from some *occult* quality in its nature, hitherto undiscovered by *philosophers*, which it chooses to exert in narrow and not in wide channels. It was something propitious that he found such effects from it at the time of his observations; had he happened to have made them in some preceding years, he might not have met with such instances of the power of water in that part of the channel, as to have removed the doubt he had of the increase of its power, when acting in a confined channel.

In the year 1725, about fifteen years after the fall of *Denver sluice*, the bottom of the river from *Stow* upwards, was in many places

too high for the *neep tides* to reach, and gangs of barges lay *aground* for several days together, and were obliged to wait till the *spring tides* put up. (See *Badeslade's hist.* page 91.)

From that time to about the year 1752, that part of the rivet seems to have grown deeper, as appears by Mr. *Kinderly's State of the Navigation*, printed in the year 1751, page 38, in which he says, " the river Ouse so far as it is
 " not above 200 feet broad, is a deep river,
 " from seven and eight, to nine feet deep at
 " low-water from *Denver* to *Germans* and *Eau-*
 " *Brink*; but when it expands to more than
 " half a mile wide for six miles near *Lynn*,
 " amongst the broad sands, it is but ten,
 " twelve, and fourteen inches deep at low-
 " water in many places in the channel. As
 " to that bar of sand which lies between *Lynn*
 " and *Germans*, though sometimes it be less,
 " as in very wet seasons, or several wet winters,
 " when the freshes were so great as to carry
 " off a part of it, so that it has but six feet, or
 " perhaps under; yet in a very dry time, it
 " quickly increases again to the height of eight,
 " and sometimes ten feet. Such was the state of
 " this river, says this author, not many years ago
 " and we don't suppose it is much better since".

Here it is to be observed, that the wide part of the river between *Germans* and *Lynn*, which for near four hundred years before the erecting of *Denver sluice*, had been increasing in depth as well as breadth, when it was deprived of the free descent of the freshes, occasioned

sioned by that *sluice* and *dam*, with the great quantity of *tide water* received into, and returned from the large and numerous *receptacles* lying *above* it, and only depended upon the small receptacle of the *New Bedford*; the tide waters received into and returned from that, were not of sufficient weight and force to maintain any certain and constant channel, or to overcome the resistance they frequently met in their way. By this reason the direction of their courses was continually altering, and by many accidents the water was often divided into small inefficacious streams, and the state of this part of the channel came to decay, and was continually fluctuating, as a greater or a lesser quantity of freshes joined the small returning *ebbs*. Nor were the upper parts of the channel between *Denver sluice* and *Germans* altogether free from such like changes, notwithstanding the confinement of its channel. Mr. *Kinderly* informs us, that after the rebuilding of the present *sluice* at *Denver*, and his *history* of the *Navigation* was ready for the press, (which was about the year 1751) “ He
 “ received letters from several people of reputation, who resided near the *Ouse*, and frequently conversed with the watermen who
 “ used it; who were unanimous in asserting,
 “ That the river was then *already* much fuller
 “ of sand, particularly between *Denver* and
 “ *Stow bridge*, than it was, before the sluice
 “ was erected.”

I have

I have been credibly informed by a person who for several years navigated the river *Ouse*, that in the years 1758 and 1759, but more particularly in the latter, the river between *Denver sluice* and *Germans' bridge* was so silted up and *shallow*, that in several places between *Downham bridge* and *Stow bridge*, and between *Stow bridge* and *Magdalen* there was not above eight inches depth of water at *low-water*; and in the neep tides the water flowed only about *eight inches*, and the gangs and boats have been constantly stopped during the time of the *Neep tides*, until the return of the *spring tides*.

This plainly shews that the scouring and deepening of *narrow* as well as *wide* channels depends upon the *quantity* and *velocity* of the *water* which passes through them; therefore whatever *diminishes* the one without increasing the other must be prejudicial to a channel; where *soil*, *sullage*, or *sand*, is brought along with the water it must occasion a dropping and subsidence of it, and contribute to the choaking it up, as also the making it *shallow*.

It is with water as with all other material *bodies*, its *momentum*, force, and moving *power*, is composed of its quantity of *matter* and *velocity conjointly*; for this reason it is, that where the quantity of matter and the velocity are proportionably great, its power will be as sufficient to grind down and *deepen* a *wide channel*, as a smaller quantity with the same velocity will be to scour and preserve a *narrow channel*.

By

By the great quantities of tides and ebbs constantly received into, and discharged out of the large and *wide rivers*, of *Severn*, *Thames*, and *Humber*, in conjunction with the water supplied by the small brooks and springs, together with the floods *sometimes* showered down by hasty rains, these great rivers have been for a long series of years constantly scoured and ground down, and made *deep* as well as *wide*.

The depth of a channel is not always owing to its *narrowness*, as some *wide* channels are much *deeper* than some *narrow* ones ; but the depth of channels is owing to the quantity or the velocity of the water which passes through them ; or more properly, as has been said before, to *both conjointly*. Where the same quantity of water which passes through a wide channel is passed through a narrow one of the same depth, in the same time, it must necessarily move with a greater velocity ; which velocity being increased, the power of grinding will be increased ; for the power of currents in disturbing or raising the soil in the channels of rivers, or rolling it along when it is raised, is proportional to the quantity of the water rubbing against it in a given time, and the velocity with which it strikes the particles of the soil.

Mr. *Golborne* seems now to think that the ideas of *narrow* and *deep*, and *wide* and *shallow* are *inseparable* ; though he once hesitated about it, and his observations on the present state of the channel from *Denver sluice* to *Eau brink* he

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thinks

thinks. have made it indubitable; but besides what has been before said of the alterations in that part of channel, Mr. Golborne should have recourse to the observations he made in the *New Bedford river*, where speaking of *Welmore lake sluice*, (p. 3) he says, “ we measured
 “ the width and depth three miles above, and
 “ found it sixty-seven feet wide, and five
 “ feet deep. From thence to *Welmore lake*
 “ *sluice*, it sounded from four feet eight to six
 “ feet deep, with a very uneven bottom; but
 “ no sooner had we passed the sluice, than the
 “ *breadth increased* to one hundred and seven
 “ feet, and the *depth* was from *six* to *fourteen*
 “ *feet.*”

This is a plain proof that the ideas of *narrow* and *deep*, and *wide* and *shallow* are not always to be connected, as the effects depend upon certain particular circumstances as have been before observed.

Having shewn the bad effects of the *New Bedford river* and *Denver sluice* in preventing the *free descent* of the fresh waters out of the *South level*, I shall next consider their effects upon the lower part of the *river* and the *outfall*.

As Mr. Golborne expects the *outfall* will receive great advantages from the *flux* and *reflux* of an additional *column* of *water*, received into and discharged out of the *New Bedford river* twice in twenty-four hours; which he estimates at near forty miles in length of the breadth of the river, and eight feet deep at the upper end; he must allow that if a greater
 quantity

quantity was formerly admitted into and discharged out of much larger *receptacles* in the same time, it must have had a much greater and better effect in scouring and deepening the *channel*, and preserving the *outfall*.

The receptacles, which the tides flowed into above the place where *Denver sluice* was erected, were the *Ouse*, into which it flowed (according to authentic testimonies to be met with in *Badeslade* page 50) about twenty miles; into *Mildenhall river* about eight miles; into *Brandon* about ten miles; into *Stoke* about six miles.

At *Salters' Lode*, which is but about half a mile below *Denver sluice*, before the erection of that sluice, an ordinary spring tide flowed about *twelve feet*; and at *Harrimere*, the place where the *Great Ouse* used to join the *Grant*, about twenty miles above *Denver sluice*, the water by such tides was raised about *four feet*. (See *Badeslade's hist.* p. 12).

From which circumstances a *probable calculation* may be made of the quantity of the tide water admitted into the afore-mentioned *receptacles*, and a reasonable comparison may be drawn between that quantity and the quantity at first received into the *New Bedford river*, as likewise between that and the quantity which *Mr. Golborne* supposes will be received into it by means of the intended *new cut* from *Eau-brink* to *Lynn*.

The river *Ouse*, where *Denver sluice* now stands, was about one hundred and fifty feet

wide; it may reasonably be supposed that it might be about one hundred and thirty feet wide at least, upon an average from thence up to *Harrimere* for the length of about twenty miles; the flow of the tide being twelve feet at *Denver sluice*, and four feet at *Harrimere* makes the mean *flow* to be *eight feet*. This constitutes a quantity of *tide water* equal to a column of eight feet in *depth*, one hundred and thirty feet in *breadth*, and twenty miles in *length*. If it be supposed (as I have not examined the dimensions) that *Mildenball river* is upon an average about thirty feet wide, so far as the tides flowed into it. *viz.* to the distance of eight miles; and that the mean flow of the water was about four feet, the same as at *Harrimere*, the quantity of water flowing into it would be equal to a column of four feet in *depth*, thirty feet in *breadth*, and eight miles in *length*.

If *Brandon river* be supposed to have been forty feet in breadth, as far as the tides flowed into it, which is before stated to be about ten miles, though from several testimonies to be met with in *Badeslade's hist.* it appears to have been much more; and if the mean flow of the tides into it be stated at *six feet*, as it approaches nearer to *Denver sluice*, where the flow is stated at *twelve feet*. This was the most principal river in the *South level* next to the *Great Ouse*, being formerly denominated the *Little Ouse*; the quantity of tide water received into it, will be equal to a column of
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six feet in *depth*, forty feet in *breadth*, and ten miles in *length*.

If *Stoke* river be supposed to be *twenty-five* feet in breadth upon an average, so far as the tides flowed into it, which is stated at about *six* miles; and as that is still much nearer *Denver sluice* where the flow of the tide is stated at *twelve* feet, let the medium flow be stated at *eight* feet; this will make the quantity of tide water received into it equal to a *column* of eight feet in depth, twenty-five feet in *breadth*, and *six* miles in *length*.

All these quantities added together, and *all* their dimensions being duly taken into consideration, they will make a quantity of tide water equal to a column of near *seven* feet in *depth*, *seventy-seven* feet in *breadth*, and *forty-four* miles in *length*.

This was the quantity of the tide water, which every ordinary spring tide the lower part of the channel and the outfall was deprived of, by setting down *Denver sluice*, as near as can be determined by a very moderate and *probable* estimate; for mathematical exactness in such cases is not to be expected.

Now let it be considered what receptacles were substituted in lieu of those taken away; there was a *new* river made upon the *higher* ground, about five or six feet in depth, one hundred feet in breadth, and about twenty miles in *length*.

The low water-mark in the old river was ten feet under *soil*, and the depth of the water
at

at that time was about four feet ; consequently the bottom of the old river was fourteen feet under soil, which was eight feet lower than the bottom of the *New river* ; for which reason it is said, there was a *dam* of *eight feet* high made in the *Old river*, to bring its bottom to the same hanging level with that of the *new one*. (See *Badeflade's hist.* p. 68 and 69). As the tide flowed twelve feet at *Denver sluice*, and the bottom of the *New river* was four feet higher than the low water-mark in the *Old one*, the tide must rise four feet before it came to a level with the bottom of the *New cut*. What water there might be in the *New river* at the time of *low water* is uncertain, but it may reasonably be supposed it might be at least two feet, (as the aforesaid dam must have raised the low water-mark answerable to the water descending in the *New river*) ; if so, the tide must rise six feet above the ancient low water-mark at *Denver sluice*, before it could proceed up the *New River*. As the tides before and at the time of setting down *Denver sluice* flowed about five hours and an half at *Lynn*, (see *Badeflade's hist.* p. 61) if it be admitted that it flowed four hours at *Denver sluice* it is as much as can reasonably be allowed ; therefore its time of flowing into the *New Bedford river* may be supposed about two hours ; and as that river was made (nothing appearing to the contrary) of an uniform depth of six feet under *soil*, it must necessarily have had the same *declivity* with the surface of the lands

lands through which it was cut, which, according to *Badeslade* was about six inches per mile. (See page 18 of his history). He says in such an *easy descent* the motion would hardly be *perceptible*, (see page 83) if it is allowed, as in this case it well enough may, that the tide flowed to near a level height; it will then follow from the proportional activity of *that river*, that the tides flowed about twelve miles into it, which is agreeable to what is mentioned in *Badeslade's history* (page 57). But to make the most of it let it be stated at fifteen miles, according to evidence given in before the *House of Commons* in opposition to a petition presented by the *corporation of Lynn*, for the removal of *Denver sluice*, in the year 1696; (see page 70, of the aforesaid history). From these circumstances it will appear that the quantity of tide water received into that river in an ordinary *spring tide* was equal to a column of three feet in depth upon an average; but to make allowance for some small differences in the time of flowing, and other minute circumstances, not easily brought into account, let it be estimated at four feet in depth, one hundred feet in breadth, and fifteen miles in length. Such a quantity is little more than one fourth part, that every such tide put into the ancient receptacles before the building of *Denver sluice* across the natural *Great river* below them all. But though so great an abatement of the ebbs repeated twice in every twenty-four hours during the course of the spring

spring tides must have been very prejudicial to the lower parts of the *channel* and the *outfall*, and must have occasioned them to *silt* up and grow *shallow*, yet these were not all the ill effects which arose from this *pernicious work*.

The *New Bedford river* being cut so shallow that the spring tides could not enter it until they had risen at the sluice near half the time of their flowing, during that time, all the water which came to that place, and all the water which did not enter the *New river* during the time of its flowing was entirely stopped, and made stagnant, for want of force to keep it in motion; and suspending the *siltage* and *sand* with which the water was loaded, and which it had copiously *rolled up*, it *subsided* and *settled*, by the sluice doors being kept shut until near low water, and the freshes at the first opening descending very slowly out of the *South level*. The ebbs in the new river immediately following the falling of the water at the *sluice*, and subsiding gently with it, (as is always the case where the limits of *high water* are not far distant from one another) the quantity of the subsided soil and sand was *too great*, and it became too well *settled* to be all removed and carried away by the return of the *ebbs*; for which reason that part of the river must have been sooner and at first more silted up than the *lower parts*. That it was so in fact, appears by the historical accounts of it. *Badeslade* (in p. 85 of his history) says, "Hence it came to pass, " the river silted up more between *Salter's*

" lode

“*lode* and *Lynn*, than between *Lynn* and the
 “*sea*.” However the ill effects of these works
 soon became general ; the river *Ouse* both above
 and below the sluice, which for about four
 hundred years, at least, before, had been con-
 tinually improving, and growing both *wider*
 and *deeper*, insomuch that Sir *Clement Edmonds*,
 upon the view taken in 1618, before these
 works were done, pronounced it to be *the best*
sewer of all that country ; and reported, that
the country along the river side, both in Cam-
bridgeshire and the isle, being a very rich soil,
well inhabited, and not otherwise much troubled
with water but in winter, and by land floods.
 (See *Badelade* p. 29). All the rivers in a
 short time became choaked and filted up, and
 the drains for the discharge of the water were
 stopped. Their channels being formerly free
 and open received such quantities of water by
 the flood from sea, that large barges and vessels
 containing from twenty six to thirty chaldrons
 of coals were navigated with great ease up to
Cambridge.

These and such like vessels were so quick in
 their passage, and so frequent in their returns
 to and from *Cambridge*, and all other places
 which the navigation extended to, that four-
 score sail of ships and barks from two hundred
 tons downward, have made fifteen or eighteen
 voyages in a year to *Newcastle* for *coals* and
salt, by the dispatch that has been given them
 at *Lynn* by these means. In that part of the
 river between *Lynn* and *Salter's lode* great
 H barges

barges and keels used to pass at *low water*. In *Lynn* harbour the ships rode afloat at *low-water*, and the ebbs were so rapid that they were obliged to be moored with a cable *extraordinary*. (See *Badeflade's* hist. p. 56, 60, 65.)

After the *New Bedford river* was cut, and the *Hermitage* and *Denver sluices* were set down, the rivers received immediate damage; the free *descent* of the waters out of the *South level* was prevented; and from being only troubled with water in *winter*, and in the time of floods, it is become, in a great measure, continually surrounded, as Mr. *Golborne* in his report very well describes.

The large *barges* and *keels* employed in navigation were soon obliged to be laid aside, and small boats of eight or ten chaldron of coals were substituted in their stead; and even *they* were navigated with great difficulty, charge, and delay for want of *water*. The channel between *Lynn* and *Salter's lode*, where large barges and keels used to pass at *low water*, such vessels could not pass at *high water*. Indeed, as I have before observed, the ill effects of these works became *general*, which may be seen by the historical account given of them, and the many authentic testimonies to be met with in *Badeflade's history*, to which I must, for further satisfaction, beg leave to refer the reader.

These are the works which Mr. *Golborne* will undertake to vindicate the *idea* of, as
founded

founded upon sound *principles*, and according to the established rule of *draining*.

A general *rule* for *draining* laid down by Sir *Cornelius Vermuyden* himself, (in his discourse on the *draining* of the *fens*, page 7) is the *imbanking all the rivers on each side, and leading away the downfall by drains and sluices*.

How far these works which Mr. *Golborne* undertakes to vindicate the *idea* of, agree with this general rule for *draining* must be left to his own consideration.

Mr. *Golborne* in page 8 of his report takes occasion to observe, that Mr. *Badeslade* has endeavoured to prove that *Denver sluice* was the cause of the loss of the *outfall*.

That *Denver sluice* and the New *Bedford river* were not only the cause of the loss of the *outfall*, but of silting up the *river* below it, the decay of the rivers in the South level above it, and the hinderance of the free descent of the waters out of it, has been proved by the *reasons* and *facts* before advanced; it is also confirmed by many other remarks which Mr. *Badeslade* has collected, as well as by the opinion of other persons of known abilities, and great experience in the operation of *tides*, and the principles of *drainage*, founded upon the observations they have made of these works.

Mr. *Labelye* having examined and taken a view of the *great level* of the *fens*, speaking of *Denver sluice*, pages 19 and 20, says, "But
" the reader must excuse me if I dwell a little
" longer upon *Denver sluice*, and describe it a

“ little more; for to that *ill-formed*, and still
 “ worse executed *project*, I cannot help attri-
 “ buting the greatest part of the *mischiefs* that
 “ have ensued, *viz.* The almost total loss of
 “ an *outfall* to the *fens*, the *ruin* of the *naviga-*
 “ *tion* to *Lynn*, and the deplorable state of the
 “ *fens*, especially the *South level* in very wet
 “ years or after an extraordinary tide.”

After assigning the reasons for his opinion, he concludes, and says, “ Whoever was the
 “ director of this work, whether *Sir Cornelius*
 “ himself, or as he had been told, *Sir John*
 “ *Frith*, of the borough of *Southwark*, (a man
 “ famous amongst the *boys* for his celebrated
 “ *Fleet ditch*) he must be taxed with an igno-
 “ rance which was almost *criminal*, if the
 “ *mischiefs* and ill *consequences* thereof are at-
 “ tended to.

From the observations of some others, it has been asserted, *that the art of man could not have contrived two more pernicious engines than Denver sluice and the Hundred-foot, (i. e. the New Bedford river) to ruin navigation and drainage.* (Badeslade's hist. page 82).

These are the works which Mr. Golborne undertakes to vindicate the idea of, though he has not advanced one reason in support of them, but only his assertion, that they were founded upon sound reason, and according to the established principles of drainage, which he says, IS TO LEAD THE WATERS BY THEIR SHORTEST COURSE TO THEIR OUTFALL.

I should

I should be glad to know whether Mr. Golborne conceives this maxim to be always right, in all cases respecting *drainage*; whether, if the shortest course to the outfall was over much the *highest* land, or over an hill, it would be more advantageous to the draining of a low flat of land, than to take a more round about *course* in a *lower situation*.

But in opposition to all this reasoning and *facts*, Mr. Golborne puts a question which he seems to think, must entirely overturn the whole.

Mr. Badelade, says he, endeavours to prove, that *Denver sluice* was the cause of the loss of the outfall. If so, says he, *How comes it that after the sluice was blown up, it was not recovered again? for though the breach might not be so wide as the old river was formerly, yet the new Bedford river being open, must receive as much water as would balance the loss of the quantity prevented from flowing through the breach at Denver sluice; and why is it, that with all the waters, the river was not improved, and the outfall recovered?*

Here are two questions proposed, which without attending for the present to what Mr. Badelade may have said about them, I shall a little consider.

The first question is, How it comes about that after the sluice was blown up, the outfall was not recovered again?

The second question is no more than a repetition of the first.

The

The inquiry is rested upon this foundation ; if after the blowing up of the sluice, the tide waters received into the rivers above it were as large in quantity, as they were before the sluice was erected, (as Mr. Golborne supposes they were,) how comes it, that from the same quantity of tide water received, the same effects should not be produced, which had taken place before the erection of the sluice ; that is, how did it happen that the lower part of the channel was not in like manner improved and the outfall recovered.

For a solution of this question it is necessary to know, what was the condition and state of the *channel* and *outfall* at or about the time the sluice was blown up, and the alteration that was made in the channel at that place by its fall.

Immediately after *Denver sluice* was erected, the river below it was filted up *eight feet*, to an hanging level with the bottom of the *New Bedford river*. From that time following, the river between that sluice and *Lynn*, and the harbour and channel below the town were continually growing worse; insomuch that part of the channel in the harbour was in a few years entirely lost, and that to the sea was greatly damaged. The mouths of the *drains* and *gools* in *Marsh-land*, by which the lands were drained into the *Ouse*, between *Denver sluice* and *Lynn*, were all stopped, and filted up, and the river as has been before observed brought into a general decay, as may be seen in the *history* before referred to; it must follow of course

course, that at the time of the blowing up of that *fluice*, the river was in a very bad state; the bottom was at least eight feet higher at that place than it was before the fluice was erected, when the tides used to flow *twelve feet* above low water-mark; that is, as the depth of the water at low water was then four feet, it rose sixteen feet *above* the then bottom; and if there was at the time of the blowing up of the fluice, only two feet water at low water, the spring tides could rise only six feet, the same as before mentioned at the mouth of the *New Bedford*. The declivity of that river having been estimated at about six inches per *mile*, and as the course of the old river from the *Hermitage* to *Denver fluice* was about *thirty miles*, and that of the new river is only about *twenty*, it must be allowed that the proportional declivity of the *old channel* is *less* in proportion, as its course is longer than that of the *new one*. Therefore it may reasonably be estimated at about four inches in a mile; and if it be admitted that the tide received into that channel upon the blowing up of the fluice might rise nearly to a level with the high water-mark there, it would follow that the tide would then flow in that river about eighteen miles above *Denver fluice*; not that these estimates can be supposed accurate, or mathematically true, but being founded upon probabilities and a parity of reasoning, they now stand much preferable to mere conjectures, and may convey clearer ideas of comparison into the mind than can be made without them.

From

From these circumstances it will follow, that the quantity of the *tide water* received into the *old river* upon the blowing up of the sluice, in an ordinary spring tide, (such a one as used to rise twelve feet before the sluice was erected) would be equal to a column of water of the average depth of three feet; and (if the entrance of the river had been quite clear) of the breadth of one hundred and fifty feet, and eighteen miles in length; but as the water-ways, in that part of the sluice which was left standing, were in the whole but *eighty feet*, and much rubbish was left in the river, which greatly obstructed the influx and reflux of the tide, (see Badeslade's hist. page 86) considerable abatement might reasonably be made on that account; but letting it remain as above stated, if to the quantity of tide water received into the *old river* be added that received into the *New Bedford*, as has been before stated, the sum of those quantities will be equal to a column of water of three feet in depth, one hundred and twenty seven feet in breadth, and thirty three miles in length; but it has been before shewn, that the quantity of tide water admitted into the several ancient receptacles above *Denver sluice* before it was erected, in the course of such a tide as is before mentioned, was equal to a column of water of *seven feet* in depth, *seventy-seven feet* in breadth, and *forty four* miles in length; more in proportion by about 100 to 53, or nearly twice as much as was received into the *New Bedford* and the *Old river* together,

ther, at the time of the blowing up of the sluice.

This of itself affords a sufficient answer to Mr. Golborne's question, *viz. Why is it that with all the waters the river was not improved and the outfall recovered?* The answer is, there was little more than *half* the quantity, and *not* half the force and power to effect it.

However this addition had for a time a proportional effect; for in the first two years after the fall of the *sluice*, being *dry* years, the river was considerably scoured out, and *deepened*, in-
 somuch that the outlets for the waters “ from
 “ the hundreds of *Marshland* and *Clackclose*
 “ into the *Ouse* between *Salters' Lode* and
 “ *Lynn*, which half a century past had lost
 “ their way to sea, began to find it again. Na-
 vigation in the lower part of the river between
Denver sluice and *Lynn* became more certain,
 easy, and less chargeable, though it was only
 the spring tides which were received into either
 the new or the old rivers, the bottom of the
 river below the sluice having been long filted
 up too high for the Neep tides to reach them.
 From the *higher* situation of the *New Bedford*
river it happened, that by the more early ebb-
 ing of the water in it, and by the freer admis-
 sion it had into the *old river*, than it could have
 during the flow of the tide down towards
Lynn, it joined the *tide water* still flowing in-
 to the *old river*, and *reverted* with it, for the
 space of about an hour every tide. Wet sea-
 sons succeeding those dry years, the land floods
 I which

which had been prevented from reverting into the river, whilst the sluice was standing, took their free course through the remains of the sluice. In November and December 1720, the land floods coming down the *New Bedford*, ran violently up the *old river* without any intermission for twenty-one days together; and by these means the bottom of the old river above the sluice, by the great quantity of *soil* and *silt* forced into it was soon raised almost as high as the surface of the *fens*: this in the year 1695 was proved by plumbing in the presence of the late Sir *Henry Hobart*, Mr. *Walpole*, &c. to have been ten feet deeper than the bottom on the *Lynn* side, which ten feet were silted up in the compass of six years; three or four feet of which were raised with the *silt* carried in in the *twenty-one* days aforesaid. The bottom of the river being thus raised, a great part of the water, which before was received into the *old river* in the course of the spring tides, was shut out; for want of the returns of which the lower part of the river grew up again, and the *outlets* of the *Marshland* waters between *Salter's Lode* and *Lynn* were all choaked up. (See *Badeslade's hist.* p. 86 and 87.)

In August 1723, it was found by boring, that the apron or sole of a sluice at the end of *Rightforth Lode* near *Stow bridge*, which by an order of sewers made at *Lynn*, September 26, 1611, 9th of *James I.* was laid one foot under low water-mark, as it usually run in the month of *August*. This was found to be eight feet
nine

nine inches *lower* than the *low water-mark* in the Ouse at the time of *boring*. There formerly had been a depth of four feet water at low water; whereas at that time there was only about *six inches*. This proves, that the low water mark at that place was raised in about the space of one hundred and twelve years *seven feet nine inches*, and that in the same time the bottom of the river had been raised and filted up about *ten feet nine inches*. (See the aforesaid Author, page 11).

As the land floods brought down the *New Bedford river* in the year 1720, ran up and reverted into the *old river*, towards *Cambridge*, for twenty-one days together, upon the return of such *floods* they continued to do the like. It appears by a view taken in January, 1723, by Mr. *Badeslade*, and several other *gentlemen*, by the direction of the *Mayor* and chief *Magistrates* of the burgh and port of *Lynn*, that the fresh floods descending along the *New Bedford*, instead of taking their due course towards the sea, did then run violently through the remains of *Denver sluice*, towards *Ely* and *Cambridge*; and continued to do so from the first of their arrival, till the flood from sea came up to that place; then both the *tide* from sea and *land floods* united, and ran together towards *Cambridge*. But the tide did not put up, or set into the *Hundred foot*, or *New Bedford river* at all. In which manner they were informed, that the *tides* and *land floods* had run towards *Cambridge*, for at least a week together, before

they came to take the view, and they continued running so for about a week after, when they went to take a second view.

A great quantity of *soil* and *silt* being carried into the *old river*, by the fresh waters descending the *New Bedford river* in the time of *land floods*, and the tides from sea joining them in their *retrograde course*, without making their due returns to sea, the bottom of the *old river* was continually more and more raised and *silted up*; so that in August, 1723, it was found that the low water mark at that season of the year though *lower* than *ordinary*, was above one foot *higher* than the *soil* of the *fens*. (See Badeslade's hist. p. 92 and 93.)

From these circumstances it will not be very difficult to account for the difference of the flowing of the like tide at *Denver sluice*, in the different years of 1723 and 1777.

Before the erecting of *Denver sluice* the low water mark was ten feet under *soil*, and an ordinary spring tide then rose *twelve feet*; that is two feet *above soil*. In August 1722, the low water mark at that place was one foot higher than the *soil*, consequently a like tide could then flow only one foot above *low water-mark*, and the low water mark at that time was *lower* than ordinary. On the 22d of August, 1723, when the *bottom* of the *river* was *higher* than the *soil* of the *fens*, it was observed by Mr Badeslade, that a tide which flowed *fourteen feet four inches* at *Lynn* rose only *one foot ten inches* at *Denver sluice*, and that it flowed

or

or run through the remains of the *sluice* one hour after it had done flowing into the *New Bedford river*; that is for the space of *two hours* and *thirty-four minutes* in the *whole*, from the time of its first beginning to *flow*. From the time of its beginning to flow to the time of high water was observed to be *one hour* and *thirty-four minutes*, and it was always observed to be high water in the *New Bedford river* before it was high water at *Denver sluice*, therefore the time of the tides flowing into the *old river* could not be more, than what is above-mentioned.

On 25th of *June* 1777, Mr. *Golborne* observed, that a tide which flowed at *Lynn fourteen feet three inches*, then flowed at *Denver sluice seven feet two inches*; making a difference in the height of the flowing of *five feet four inches* from the former. Mr. *Golborne* requires to know how this difference is to be accounted for.

I believe from what has been before said, it will not be hard to conceive, that it may easily be accounted for. But to come more immediately to the point. By the *levels* taken in April, 1776, I found the low water-mark in the *Ouse* just below *Denver sluice* to be about *five feet* under *soil*, and the depth of the water at low water was *eleven feet*. In October following it was something altered, and the depth of the water was *nine feet*; and Mr. *Golborne* says, by his sounding in 1777, he found the depth from the end of the *New Bedford* to *Salter's Lode sluice* to be from *seven* to *seventeen feet*;

feet; that is about *seven feet* at the *mouth* of the *New Bedford*. In October, 1776, when the depth of the water was *nine feet*, the low water mark was found to be near *six feet* under *soil*. If it is admitted that the low water-mark was nearly the same at the time Mr. Golborne observed, though according to the sounding it may be supposed to be something *lower*, it appears, that the *high water* mark when Mr. Golborne made his observation, in June 1777, was only one foot three inches *higher* than the *soil* of the *fens*; but in August, 1723, when Mr. *Badeslade* made his observation, the bottom of the river was grown up to be as high as the *soil* of the *fens*; consequently such a tide, as Mr. Golborne observed, must have risen *six feet* before it came to be so high as the *bottom* of the *river*, and therefore could only rise *one foot three inches* above it. The tide observed by Mr. *Badeslade* flowed *one foot ten inches*, which was seven inches more than that observed by Mr. Golborne; and it is very evident, that it was the *soil* and *silt* that had raised the bottom of the river, that occasioned the difference in the height of the flowing of those tides, and not the running into the *South level*, as Mr. Golborne suggests; for it could not possibly run into that *level at all*, till it had flowed *six feet* in height; therefore all the water that run into that *level* could not make a difference of more than one foot ten inches, supposing it had all run in as fast as it flowed without rising *at all*. According to the course of its rising it came

came nearly to the same standard that the tide which Mr. *Golborne* observed *rose to*; but as it run through a contracted channel into a more expanded receptacle, its motion would be accelerated, and it would not rise so fast at *Denver sluice* as in the *New Bedford river*, and the tide would arrive at its greatest height in that river before it did at *Denver sluice*. The ebb sooner descending reverted with the flowing water through the remains of the sluice, until the water to *sea-ward*, as Mr. *Golborne* rightly observes, had subsided so low as to prevent it. The water flowing in for about the space of two hours, at the depth of *one foot ten inches*, could never be the occasion of a difference of *five feet four inches* in the height of the flowing of the two different tides before-mentioned; for to have done that, the tide must have run through the remains of *Denver sluice* almost as fast as it rose from the first of its flowing; which it could not possibly do, as the bottom of the river was grown up six feet *above* the low water-mark at the time of Mr. *Golborne's* observation.

How Mr. *Golborne* from such a distressed state of the *river* and the *south level*, so evidently occasioned by the effects of *Denver sluice* and *New Bedford river*, could infer, that the *outfall* could receive no advantage from the tides flowing into the *south level*, if *Denver sluice* was removed, the tides received into their antient receptacles, the level properly im-
banked

banked, the rivers *deepened*, and the free descent of the *land floods* through that *level* not hindered by the waters of the *Ouse* flowing so rapidly down the *New Bedford river*. The event plainly shewed and proved, that before the *New Bedford river* was cut, for turning the water of the *Great Ouse* out of its old natural course, and the setting down of the *Hermitage* and *Denver sluices*, that the *river* above, and the *channel* below, were continually wearing *deeper* and *larger*; the outfall continually *improving*, for three or four hundred, nay, according to very good accounts, six or eight hundred years successively, down to the very time of executing these works; and that without *imbankments*, or very little, if any assistance of *art*, is indeed very *remarkable*; especially when it has been so plainly shewn, that all the mischiefs and injuries which arose after the falling of *Denver sluice*, were owing to the ill effects that *it* and the *New Bedford river* jointly produced before, and what the latter singly occasioned *afterwards*. That there was no want of an inlet before the execution of those works is very evident, from the great quantity of tide water every ordinary spring tide conveyed into the several large and remote receptacles above the place where *Denver sluice* was put down; the whole quantity of which, upon a reasonable and probable calculation as aforesaid, equalled a column of water of seven feet in depth, seventy seven feet in breadth, and forty four miles in length, besides

fides the great quantity that filled that part of the river between *Lynn* and *Denver sluice*; some parts of which were a full *mile* in breadth, as appears by a petition presented to *Edward III*, so long ago as the year 1342. By a petition presented to king *Richard II*, it appears, that in 1378, the *haven* at *Lynn* was then 40 *perches* wide at 16 feet to the perch, the ancient width of which had been only *six perches*, and for that reason it was requested that it might be straitened. Something of this sort probably was done, but the force of the tides joined with the great quantity of the freshes, soon enlarged it again; and by a verdict of sewers held at *Well* and *Stowbardolph*, in the year 1596, in the 8th of *Elizabeth*, it was said, that the banks of *Marshland* could not then be preserved, without there was some provision made for straitening *Lynn haven*, which was then wider than it was wont to be, and caused the flood to rise at *Salters' lode* one foot higher than it was wont to do within twenty years preceding. Upon a view taken by the commissioners of sewers the 14th of August, 1618, of the river *Ouse* from *Salters' lode* to the outfall at *Lynn*, they found a very large and quick river, much increased in depth and breadth. (See *Badeslade's* hist. page 7). Sir *Clement Edmonds*, in his report to the lords of the *privy council*, from a view of the commissioners of sewers taken in the same year and month, at which he was present, says, The river *Ouse* coming along by the towns of *Bedford*, *Huntington* and *St. Ives*, and so passing

ing down to its outfall at *Lynn*, is a goodly fair river throughout, and from below Ely downward runneth with such a current, that it is absolutely the *best sewer* of all that *country*; and along by the river side, tis a very rich soil, both in *Cambridgeshire* and the *Isle*, and not otherwise much troubled with water, but in *winter*, and in time of *floods*; and would not have happened probably but for the *weeds*, *weeres*, and *hardes* in the river, which obstructed the passage of the waters. *For the outfall of the river Ouse is ample and great, and gives large passage for the waters descending from the inland countries: but then also for the sea, which cometh in with such a tide, especially if a northerly wind blows, and it meets with a land flood, that divers towns in Marshland are in danger of being overflowed and surrounded; and therefore by their petition desired, that the haven might be straitened in some place near Lynn to keep out the sea; alledging, that the said haven had, in the memory of man, been narrower and shallower, than it was at that time.* (Badeslade's hist. page 11). That the outfall is now as *open* and *large* as ever it was, and has for some time been continually *enlarging*, so that the admission of the tides has been greatly increased, and the waters have risen considerably higher, than in the memory of man, they have been wont to do, is a circumstance commonly known to navigators, and all others acquainted with the harbour of *Lynn*, who have made any observations upon them.

The

The want of a proper and sufficient inlet for the *tides*, has not occasioned the obstructions which Mr. *Golborne* so emphatically complains of, but the hinderance of the free descent of the *freshes* out of the *south level*, and the stoppage of the *tides* out of the large *receptacles* above *Denver sluice*, which they anciently used to fill twice in twenty four hours. There does not appear to be the least reason to doubt, but as those two powers joined formerly improved a *narrow* and *shallow* channel, of only about *four* or *six poles* wide, to a *deep* and *wide one*, of about a mile in breadth, and so maintained it for some hundreds of years; I say, there is no reason to doubt, if those two powers were again properly united, they would be sufficient to remove all obstructions, and recover a *deep channel* and a good *outfall*. If nothing more is wanted than a sufficient quantity of water to descend in the last *quarter's ebb*, this is much more likely to perform it than what can be received into the *New Bedford only*, by the new cut from *Eau Brink* to *Lynn*, which Mr. *Golborne* proposes; or as I apprehend, by any other means which can be thought of, not even if it were possible to force into it such a column of water as would flow eight feet in depth at *Earith*. This however I apprehend to be altogether impossible, without the bottom of the river was to be *lowered* nine feet at *Earith*, and so less in proportion downward, that the whole present fall of nine feet might be destroyed, and the bottom brought upon or under the hori-

zontal *level* with the present low water-mark at *Denver sluice*. Then such a tide as now flows there about eight feet, might flow nearly as much at *Earith*; and if the low water-mark at *Denver sluice* was reduced four feet lower than it now is, it would have a fall of four feet, which is about two inches and an half in a *mile* to bring it down. But Mr. *Golborne* does not mention the deepening the *New Bedford* by hand, as any part of the work which he proposes to have done, but seems to expect every thing from the *new cut* from *Eau brink* to *Lynn*, and from the effect that will have of reducing the low water-mark at *Denver sluice* four feet lower than it is at present.

If nothing is intended to be done at the bottom of the *New Bedford* in respect to deepening of it, then all that the reducing the low water-mark four feet at the *lower end* of it can possibly do in that river, is the adding four feet more *fall* to its *waters*, and bringing the present fall of *nine feet* up to *thirteen feet*, which will proportionably accelerate the velocity of the current. As the velocities of all heavy bodies, (fluids as well as solids) are increased in the proportion of the square root of the perpendicular spaces through which they descend; it in this case will be, as the square root of nine, which is equal to three, is to the square root of thirteen, which is something more than three and six tenths; so is the present velocity to the increased velocity; that is, the present velocity to the increased velocity will be nearly
in

in proportion of thirty to thirty-six, or about one fifth part greater than it now is; as in channels of equal breadth, where equal quantities of water are carried through in equal times, the depths must be in a reciprocal proportion to the velocities of their currents. It follows in this case the diminution of the depth, or the reduced depth will be to the present depth as thirty to thirty-six; that is, the present depth will be reduced about one sixth part of what it now is. In the year 1776, when I took the *levels* of the New Bedford river, the average depth between *Earith bridge* and *Sutton chain* was about six feet, the water in that part of the river would be reduced *one foot*. At *Earith bridge* the depth being then about four feet six inches, it would be reduced to about *three feet nine inches*; and the depth on the gravel at *Sutton chain*, being then about three feet, would be reduced to about *two feet six inches*, and all other parts proportionably. This would be the effect of the reduction of the low water mark at its mouth *four feet*, in respect to the low water-marks in *that river* without *deepening* the channel. With respect to the quantity of tide water which would be then received into it, if the low water-mark at its mouth was reduced four feet lower than it now is, a tide which now rises *eight feet* at that place would then rise *twelve feet* above the *low water-mark*. As the acclivity of the river would be increased, and the proportional ascent would be nearly eight inches in a *mile*, if the

water

water ascended to about the *level* with the high water-mark at its mouth, it would flow about eighteen miles into that *river*. The quantity of water received into it in one tide would be equal to a column of six feet in depth, (and to make the most of it) one hundred feet in breadth, and eighteen miles in length; which is not equal to half the quantity carried into the ancient receptacles above *Denver sluice*, which might be now laid open for it. The water indeed would descend with a superior velocity, but that effect would be lost in *Lynn haven*.

Having considered the effect of reducing the low water-mark four feet at *Denver sluice* in respect to the *New Bedford river*, without *deepening* the channel, I shall now consider, what the effect would be of deepening it in such a manner as has been before-mentioned, viz. so as that the tide may rise *eight feet* at *Earith*, and form a column of eight feet deep at the upper end. In order to effect this, it has been shewn that the channel must be deepened at least nine feet at *Earith* bridge, and proportionably less towards its mouth, which can be done no otherwise than by *manual operation*. The natural increase of the fall would not effect it, as the velocity of the current would be increased only about one *fifth part* of what it now is, and the addition will be much less in the upper than in the lower parts. Without manual operation the tides in their ordinary flow would not reach it, and therefore could

could not effect it; but admitting the channel was deepened in such a manner, as to receive a column of tide water of eight feet in depth at the upper end, every tide, the length of the *New Bedford* river is only *twenty miles*; and that is the length of the column which would be received in one tide, and two such columns are only equal to one column of forty miles in length, which would be received into it in twenty-four hours. Therefore by the word *THOROUGH*, Mr. *Golborne* must mean both the *influx* and *reflux*, and in that sense it is right to say that a column of forty miles in length would pass *through* it *twice* in twenty-four hours. In comparing quantities, the circumstances should be considered in a similar manner; and I have only compared the quantities received in one single *tide*. In the circumstances above-mentioned, if a quantity of water of eight feet in depth at the top, and twelve feet in depth at the lower end, and of the whole breadth and length of that river, was every tide received into it, such a quantity will be equal to a column of water of *ten feet* in depth upon an average, *one hundred feet* in breadth, and *twenty miles* in length. This is much less than what one tide conveyed into the ancient receptacles before the erecting of *Denver sluice*, and therefore cannot be an *equivalent* for it. Besides by lowering the bottom of the river in such a manner, the present fall of nine feet will be reduced to four,

and

and the present velocity will be abated one third part.

Having plainly shewn the impropriety of the *plan* originally adopted, and the ill effects of the *works* executed in consequence of it, with respect to the *South level*, and compared the quantity of the tide waters received into the *New Bedford river*, with the quantity formerly received into the *ancient receptacle* it flowed into, before the erection of *Denver sluice* and the execution of those works; I shall now attend to some of the observations which *Mr. Golborne* made upon his view; the conclusions he draws from them, and the *works* he recommends for the *effectual draining*, and giving the *utmost* relief to the *South* and *middle levels*.

The grand, primary, and principal object which *Mr. Golborne* has met with in his progress, is, that *calamitous* and *desolate* state of the *levels*, which is generally known, and as generally deplored. Which every friend of the community, every person of public spirit, every lover of arts, and every one concerned for the credit of the artists of this island, must wish to see remedied, and rejoice at the accomplishment of it; and must like *Mr. Golborne* sympathize with the inhabitants in their present *distress*. Look, says he, which way you will, you see nothing but misery and desolation; go but half a mile from *Ely*, and you come to *Middle fen*, a tract of sixteen thousand acres
given

given up and abandoned; there you see the ruins of windmills, the last efforts of an industrious people.

If to *Ramsay*, there you find more than ten thousand acres occupied by the waters, houses without inhabitants, and lands incapable of either pasturage or tillage.

Great, indeed! are the distresses, and much to be wished the *remedy*; and so unsuccessful hitherto have been the means, that every plan proposed for their recovery ought to be duly weighed and thoroughly *examined*.

In the course of the river *Ouse* between *Denver sluice* and *Lynn*, Mr. *Golborne* observes, that from the former place to *Eau brink*, where the river was properly confined it was *deep*, viz. from *eight* to *ten feet* in depth, but from *Eau brink* to *Lynn* where it was *wide*, he found it in general *shallow*, except in some particular very deep holes, occasioned by the checks which the current met with in rubbing against the hard and immoveable *shores*.

From these circumstances he infers, that water passing through a *narrow* channel will receive a power superior to what it can obtain in passing through a *wide* space, even where, there is little or no increase of its *velocity*; and gives an instance of the great force it receives, by passing through a confined channel, where the increase of the velocity, he supposes, can be but very *small*; as he makes a fall of only *one foot* in about *eleven miles*; (which however by the levels of the river *Ouse* which I took in 1776,

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appeared to be about *seven feet*; and in the year 1730, about forty-six years preceding, it was found by Mr. *Kinderly* to be at least *five feet*, as has been elsewhere before observed.) But it has been proved before, that water, like all other material bodies, can have no force but what it receives from its velocity and quantity *united*, and that where there is a proportional increase of these, the effects of its power are as sensible and manifest, and its operations as efficacious, in a *wide* as in a *narrow* channel; provided that the quantity and velocity are proportional to the *capacity* of it.

After the rebuilding of *Denver sluice* and the tides were prevented from running into the *South level*, that very part of the river, where Mr. *Golborne* met with such great depths of water, became so *silted up*, that the Neep tides could scarcely reach *Denver sluice*. In several parts of the river between *Denver sluice* and *Magdalen* they rose only about *eight inches*, and were so shallow that the *lighters* and *boats* were stopped for several days together, and were forced to wait the return of the *spring tides* before they could proceed. In this state it continued for several years, until of late, within the compass of about twelve or fourteen years past, owing, as may reasonably be apprehended, to two causes. The first is, the upland waters being, within about that period of time, brought down in the time of *floods* much *quicker* and in a more *united* manner than they formerly were, before the improve-
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ments in *incloſing*, *turnpike roads*, new *navigations*, and better *draining* were got into. By theſe means, that part of the river *Ouſe* paſſing through the *fens* is more frequently filled, and the waters deſcend through the *New Bedford* river, with more frequent *increase* of force. The ſecond cauſe is the conſtant and late enlargement of the *inlet* of the *tides* at the mouth of *Lynn harbour*; by which means all the large tides riſe higher than they formerly uſed to do, and conſequently flow farther into the *New Bedford*, and increaſe the force of the *ebbs*. By theſe two cauſes jointly it has happened that the narrow part of the river between *Denver ſluice* and *Germans bridge* has been greatly *deepened*, but the receptacle for the tide waters being very *ſmall*, in proportion to thoſe into which they were formerly received, the power and force was not ſufficient to take the *ſoil* raiſed in that part of the river, along with the waters down to the *ſea*. As the channel expanded, and its force weakened, the ſoil *ſubſided*, and the obſtructions below, inſtead of being reduced, became in particular places conſiderably *increaſed*. This is the reaſon, that the lower part of the river between *Eau brink* and *Lynn* continues ſo *ſhallow*, as Mr. *Golborne* found it to be; and he therefore rightly concludes, that there wants *larger* receptacles in the upper part of the river, from whence the water may return in a powerful body with great velocity in the laſt quarter's *ebb*, which was the very thing it was *deprived* of, by putting

down *Denver sluice*; and is what would be *re-stored* to it again, by the removal of that pernicious *engine*, and the proper imbankment of the *south level*.

But says Mr. *Golborne*, it would be a most difficult and expensive work, to bank out the rivers; for the whole level being brimful of *water*, there are neither materials to make banks of, nor ground for them to stand on, as the whole is moor.

From what has been already done it plainly appears, that materials may be had to make *banks* of, and ground may be found for them to *stand on*. After all, imbankment must be the method, as it has been long foretold; it certainly *must*, and no other method can *be effectual*. Let the expence be as great as it can be supposed, unless the level is quite *abandoned* and given up, it must certainly be better to adopt it at first, than after expending large sums of money in ineffectual expedients (as has hitherto all along been done) be obliged to come into it at last. If the works proposed by Mr. *Golborne* are sufficient to recover the *out-fall*, and to give the *utmost relief* to the levels, then indeed there might not be any occasion for it, and I am at a loss to know why he should recommend such an expensive work, *after* the levels have received the *utmost relief* that can be given them.

From the shallowness of the channel between *Eau Brink* and *Lynn*, (the sounding of which he has not mentioned) the increase of the fall in
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that part of the channel, and the observations he made of the different flowing of the tide, at *Lynn* and *Germans bridge*, and at *Denver sluice*, Mr. *Golborne* concludes, there is an obstruction in the *Channel*, which keeps the low water-mark at *Denver sluice* four feet higher, than it might or ought to be kept. This obstruction he concludes must lie between *Germans* and *Lynn*. According to the levels taken for him, the fall from *Denver sluice* to *Eau Brink* was only one foot, in the distance of about *eleven miles*, and from *Eau Brink* to some small distance above *Lynn*, the fall was *four feet nine inches*.

From the observations made by Mr. *Golborne* on the flowing of the tides, it was found, that a tide which flowed fifteen feet eleven inches at *Lynn*, flowed nine feet seven inches at *Germans bridge*, and seven feet nine inches at *Denver sluice*. That it ran up twenty-five minutes after high-water at *Germans bridge*, in which time it *ebbed*, (that is, it shrunk or subsided) fifteen inches there; and it was an hour and fifteen minutes in going from *Lynn* to *Germans*, (being six miles) and an hour and eight minutes in going from thence to *Denver sluice*, near ten miles; so that it went after the rate of five miles an hour from *Lynn* to *Germans*, and of ten miles from thence to *Denver sluice*.

How Mr. *Golborne* determined the difference of the time of the tides going from *Lynn* to those *places*, he has not given information.

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That the velocity he has ascribed to it is incongruous to common experience, will appear by the following considerations, viz. in a current running with such a rapidity, as after the rate of *ten miles* in an hour, it would be impossible to manage and navigate such sort of boats, fastened together one to the stern of another, in trains of *eight* or *ten* in number, which they use and navigate withal in the *river Ouse*; as they are fastened to one another with ropes in such long trains, they often swing *across* the river, and in such a rapid current would be immediately *overfet* or *sunk*, which accidents seldom happen in that part of the river. In that part between *Lynn* and *Germans*, they are too frequently met with, which obliges them to take extraordinary assistance from *Lynn*, which they generally discharge at *Magdalen bridge*. If the tide runs with such rapidity, they could be very ill spared in that part of the river; besides, these trains of boats, which are commonly called *gangs* of *lighters*, are generally haled and towed along by one, two, or more horses, walking upon the banks on each side of the river, by long lines fastened to a mast, fixed in the foremost *lighter*. In a current which runs at the rate of *ten miles* an hour, it would be utterly impossible for the horses to keep the lines strait, and free from getting foul of such things as may lie or stand on the banks in their way; besides which, the boats would be frequently getting before the horses, by which means they would be pulled *backward* instead of

of *forward*, would be swung across the river, and get foul of each other, and be overset or sunk.

Such a rapidity of tide is scarce to be met with, in any of the greater rivers on the coast of *England*, except perhaps in the *Severn* or *Bristol channel*, where they rise to the height of *thirty* or *forty feet*; in the *Thames* it is quite otherwise; though the spring tides at *London* (which is 40 or 50 miles from the sea) ordinarily rise about fourteen or sixteen feet; from observations made by Mr. *Labelye* it appears, that at *Westminster bridge* the tides flow about ten or *twelve feet*; and he found the velocity of the tide there about three feet per *second*, which is very little more than two miles in an hour.

That a tide in the river *Ouse*, which rose at *Lynn* fifteen feet and eleven inches, and had proceeded about seven miles up the river to *Germans bridge*, with a velocity of five miles an hour, should, even where it had yet an inclined plane of near one foot *more* elevation (according to Mr. *Golborne's* own account) to ascend, before its arrival at *Danver sluice*, which must necessarily, in some degree, retard its motion; I say, that it should at that place under such a circumstance, receive so surprising an increase of velocity, as to double that it arrived withal, is something remarkable. I am very well apprized, that the same quantity of water passing in the same time from a large section into a smaller, will have
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its velocity proportionally *increased*, which in its passage through *German's bridge* may be the case, as the clear water-ways at the bridge are less than the section below it. But that increase is proportionably diminished by the largeness of the section above it, as well as by the *retardation* from the acclivity of the river. If that should be greater, than Mr. Golborne makes it, as from the levels I have taken I have great reason to believe *it is*, it would be proportionably more retarded, its rapidity would be abated, and the current would become more and more *calm* and *moderate*, as the tide proceeded in its course upward, as it is generally known in *fact* to do.

But let it now be observed, how Mr. Golborne attempts to account for this great increase of velocity, which he ascribes to it, which is as follows, *viz.*

The tide, in going from *Lynn* to *German's*, must rise up an ascent of four feet nine inches, besides the shallowness of the channel; which is a considerable obstruction to the current, by the great friction against the bottom, impedes the motion, and makes it so long in passing to *German's*: whereas, when it once gets there, it has deep *water* to move along, and but *one foot* of ascent to combat with in near *ten miles*.

That the motion of water and all other heavy bodies, impelled directly upward or obliquely upon inclined planes, are by the force of gravity continually *retarded*; and that bodies impelled up a steep inclined plane of great acclivity suffer

fer a greater retardation of their motions in the same time, than those impelled with the *same* force up a plane of less acclivity; and that friction impedes the motion of bodies, are matters generally understood. Therefore, if the tide had but one foot of ascent to combat with in near ten miles from *Germans* to *Denver sluice*, sure that conflict, that impediment could not be any great *addition* to the velocity it had *lost*, by combating an ascent of four feet nine inches in its motion from *Lynn* to *Germans bridge*. Little as the impediment was, (and that it was an *impediment* Mr. Golborne acknowledges) it must be an addition to the *retardation* it had met with in its way from *Lynn* to *Germans*; therefore instead of *increasing*, it must in some proportional degree have *lessened* its velocity, and its motion could not possibly be accelerated from that *cause*. But, says Mr. Golborne, it had *deep* water to move along; well this might perhaps abate the friction, but was this deep water at *rest* or in *motion*? I believe Mr. Golborne will allow it was in *motion*; if so, I must take the liberty of making a farther inquiry, was its motion when the tide approached it, in the same direction with the motion of the tide, or in a *contrary* direction. I am apt to flatter myself, that Mr. Golborne will allow, that it was moving in a *contrary* direction; if so, it is well known that fluids and all bodies in motion meeting one another in contrary directions *impede* each others *motion*, and whatever motion is communicated from one to the other, must

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be lost from the original motion of the body which communicated it; consequently, as the quantity of the descending freshes must be greater in proportion to the increase of their *depth*, all other circumstances being alike, the deepness of the water must *increase* its *resistance*, and the greater quantity of motion must the tides *lose* to overcome it. The depth of the water is so far from being a cause of acceleration of the motion of the tides, that it must of necessity be a great cause of their *retardation*, and instead of increasing must greatly *diminish* their velocity. Therefore Mr. Golborne has either not rightly determined the velocities, or he has not hit upon the true cause of their differences, or both, which from common experience is the most probable.

As to the phænomenon which Mr. Golborne observed, of the water running up at *Germans bridge* twenty-five minutes after high water, until it had *ebbed* or *shrunk* there fifteen inches, which he imputes to the *weakness* of the force with which it arrived there; for which reason, he says, it could not fill the river upward before the ebb came on, therefore it ran *up* and ebbed as before-mentioned. He asks, if this is not a convincing proof, that the obstruction lies between *Germans* and *Lynn*. My answer is, that if the force of the tide was ever so much spent before it arrived at *Germans*, he has before concluded, that it was doubly *restored* at its arrival there; therefore if it was before too weak, it must then have received force enough
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to have filled the river upward before the *ebb* came on.

But in order to account for this phænomenon, it must be considered, that where water is flowing up a river, and comes to any section where its motion is in any degree *retarded*, either by the acclivity of the plane it is flowing up, or any other resistance, or impediment which the water below it does not meet with till it *arrives there*, it must necessarily *rise* in that section. On the contrary, if the water below it upon its arrival at that section has by any means its motion increased, and its velocity accelerated, without any increase of velocity *before it approaches*, it must necessarily *subside*. If it receives no alteration of its motion, but passes through it with the *same* velocity it approaches, it will neither rise nor *fall*, but keep its original height; in the same manner as a bason partly filled with water, which is supplied by one pipe, and emptied by another; if the quantity brought in is larger than the quantity discharged, the water originally in it will be *raised*, but if the quantity discharged exceeds the quantity supplied, the water in the bason will *subside*. If the supply be just equal to the discharge, the water in the bason will neither *rise* nor *fall*. So in the case of the tides, whilst they are rising in the lower parts of a river and their impulsive force is increasing, if upon their arrival in the sections *above*, they meet with some degree of resistance, and that constantly in the same proportion to the increase of the

impulsive force, in that part of the river they will keep rising; but if by the impulse of the tide rising in any particular section, the motion of the water above is accelerated, so as to become equal to that *below* it, the water will go from it as *fast* as it approaches it, and the water for the time of the continuance of this circumstance will neither *rise* nor *fall* in that *section*, and it will be there high water. As all bodies in motion endeavour to preserve, or must of necessity continue the motions impressed upon them, till they are altered, or destroyed by some other external force, so in this case, the water above the section having received the greatest impressed force which the impulse could impart to it, will for some time continue its motion with nearly the *same* celerity. If by the subsiding of the water in the lower parts of the channel, the velocity of the water below it is abated, so as to approach the section with a *less* velocity; when it arrives in it, and its particles unite with those of the water immediately *above* it, they will be *accelerated* by it, and will go out of the section faster, than those *below* it will *enter*. Therefore the water in the section will *subside*, notwithstanding the motion of the water *upward* is continued through it. But this motion will continue no longer than until the *retardation* of the water below the section (occasioned by the subsiding of the water in the lower and more distant parts of the channel) becomes equal to the force of acceleration it receives from the
water

water above it. Then its motion upwards will be stopped, and by the further subsiding of the water in the lower and more distant parts of the channel, by the force of its own gravity, its motion will be turned *downward*, and will be continually accelerated. So long as the celerity of the water *below* the section is greater than the celerity of the water *above* it, the motion of the water coming through it will be accelerated, and will go out of it with a *greater* velocity than it *entered*, and while it continues to do so, it will keep falling in that *section*. The cause assigned above is the reason of such phænomena, as Mr. *Golborne* observed in the flux and reflux of the tides, at *Denver sluice* and *Germans bridge*, and arises from that principle or property in all bodies, which the philosophers call their *Vis inertiae*; by which they endeavour to continue the motions which are impressed upon them, and which they cannot *lay aside*, until they are destroyed by *friction*, *resistance*, or some external equal *contrary* force.

If the tides have an ascent of four feet ten inches to rise against, in a distance of about six miles from *Lynn* to *Germans bridge*, and an ascent of less than one foot to rise against, in a distance of near ten miles from *Germans bridge* to *Denver sluice*, as Mr. *Golborne* states it, the water in the influx of the tides must certainly meet with proportionably more resistance, in its flowing between *Lynn* and *Germans*, than in its flowing between *Germans* and *Denver sluice*.
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From this state of the case it may be properly said, that the greatest obstruction to the *influx* of the tides lies between *Lynn* and *Germans*. With respect to the *reflux* of the tides, and the *descent* of the *fresh waters*, from the great increase of the fall from *Eau brink* to *Lynn* according to this state of the case, the velocity of the water in that part of the channel would be greatly *increased*, and without some great obstructions in the bottom of the river, the water by that increase of fall must be brought down more freely, than in the upper part of the channel from *Denver sluice* to *Eau brink*, where he states the fall to be so much proportionably *less*. The reason for inferring an obstruction to the descent of the *ebbs* and *freshes*, could not arise from any circumstances, but the *shallowness* of the channel he observed between *Eau brink* and *Lynn*, and the estimation of its degree cannot be founded upon the quantity of the *acclivity* or *declivity* of the *channel*, which it seems to be attributed to; as a great *acclivity* which obstructs the *influx* of the tides, being a proportionably greater *declivity* in respect to the *descending waters*, their motion must be as much *accelerated* by it, as the influx of the tides are *retarded*. Obstructions are not always to be inferred from the *shallowness* of a channel, except it exceeds a certain degree. If the quantity of water discharged through a *lower* section of a river, is equal to that discharged through an *upper* one in the same time, there can be no obstruction to the descent

scent of the water in the *lower* one. The quantity of water, discharged through different sections in the same time, is always equal to the capacity of the section, and the velocity of the water conjointly. Where the parts of a channel are of equal breadths, and the same quantity of water runs through them in the same time with unequal velocities, that part in which the velocity is the *greatest* will be *shallowest*; and yet the shallowness will be no obstruction to the descending water, as an *equal* quantity will be discharged in an *equal* time by the *increase* of the velocity. To apply this to the case of the *levels* taken for Mr. Golborne; he allows the fall from *Earith* to *Denver sluice* to be *nine feet*, and from *Denver sluice* to *Eau brink* he states it at *one foot*, which makes *ten feet*; and the fall from *Eau brink* to near *Lynn* he states at *four feet nine inches*, which added to the ten feet makes *fourteen feet nine inches* for the whole fall from *Earith* to a place near *Lynn*, where it is supposed, Mr. Kinderly intended the new cut, which he proposed should enter *Lynn haven*. Now as the velocity of all heavy bodies descending upon inclined planes, are in proportion to each other, as the square roots of the perpendicular heights of the planes on which they descend, it will be as the square root of ten, which is something more than three and sixteen hundred parts of an unit, is to the square root of fourteen feet nine inches, which is about three and eighty-four hundred like parts; so is the velocity of the water acquired

quired in coming from *Earith* to *Eau brink*, to the velocity it acquires in coming from *Earith* to *Lynn*. As the number three hundred and sixteen is in proportion to three hundred and eighty-four, so is the velocity of the water in descending from *Earith* to *Eau brink*, to its velocity in descending from *Earith* to *Lynn*, which is nearly one fifth part greater. If the average breadth of the river from *Eau brink* to *Lynn* was equal to that from *Denver sluice* to *Eau brink*, and the depth of the water in the latter part was upon an average *ten feet*, and in the former part little more than *eight feet*, the lower part would discharge as much water as the upper part brought to it. If the breadth of the river from *Eau brink* to *Lynn* was four times as great as it is from *Denver sluice* to *Eau brink*, and little more than two feet in depth, (according to Mr. *Golborne's* state of the levels) it would discharge as much water, as that part of the river from *Denver sluice* to *Eau brink* could bring down to it, at an average depth of *ten feet*. It follows therefore, that the obstructions in the different parts of a river are not to be estimated by the difference of their depths *only*, but by the difference of their depths, breadth, and velocity jointly taken; or, which is the same thing, by the capacities of their *sections* and *velocities* conjoined, or multiplied together. If these are less in one place than in another, where these products are least, there must be an obstruction. This depends upon the bottom of a river being a regular inclined plane

plane with an even surface; but where the bottom of the river is unequal, as is generally the natural state of all rivers, the elevations will hinder the descent of all the waters below the horizontal level of their summits. Such inequalities are discoverable by sounding and plumbing the water, and from one part of a channel being shallower than another, an obstruction is generally *inferred*; though from what has been said before, it may not always be right, That there are obstructions in the channel between *Germans* and *Lynn*, I believe will be doubted by few; Mr. *Kinderly* concluded it from his examinations and *levels* taken about forty-seven years since, and by the *levels* taken by me, and the section formed from them (the particulars of which, with observations on the state of the rivers, were transmitted to the *Register* office of the honourable *Corporation of Bedford level*, in the month of August, 1776, as has been before-mentioned. By that section which was delivered to Mr. *Golborne* at *Lynn*, in 1777), it appeared, that the low water-mark at *Denver sluice* was then about five feet *under* the soil of the lands on the west side of the river, and those about one mile and three quarters above it toward *Littleport*; and it being in the spring of the year, after a strong frost and a large fall of snow, the water was higher than common, and the depth in the river a little below the *sluice* was eleven feet, and consequently the bottom about sixteen feet *under soil*. The low water-mark at *Salter's*

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Lode was about four feet four inches below the same lands, and the depth of the water there was about *fourteen feet*, the bottom therefore was eighteen feet four inches *under soil*. In a view of sewers taken June 25th, 1605, above forty years before the erection of *Denver sluice*, it was found that the low water-mark was then ten feet under the soil of the *fens*, at which place the depth of the water was *four feet*, and consequently the bottom of the river was *fourteen feet under soil*. Though it may be supposed that the soil is something *higher* now than it was at that time; yet it may reasonably be concluded, that the bottom of the river at that place *now*, is considerably lower than it was at *that time*; but as the depth of water was ten feet more than it was then, the surface of the water must be about *six feet higher* than it was at that time; from which I remarked, that it evidently indicated an obstruction, some where in the *lower* part of the *channel*. As I had found by the soundings and the *levels* taken, that there was a certain place in the bottom of the river, about two miles and five furlongs below *Germands bridge*, at *Islington*, much *higher* than any other part of the river, I concluded that the greatest obstruction must lie in that place, as in my section it evidently appears to do. In that place the bottom of the river is higher, than a little below *Germands bridge* by about five feet and an half, and higher than the bottom of the river near *Magdalen bridge* about fourteen feet, and nearly as *high* as the bottom

bottom of the river just below *Denver sluice*, and full as high as the low water *mark* at *Lynn*. The several depths of the water from *Denver sluice* downward, according to the soundings then taken, were as follows, viz.

From *Denver sluice* from eleven to fourteen feet, with some smaller intermediate depths.

From *Salters' lode* to *Downham bridge* from fourteen to sixteen feet with intermediate depths of about fifteen feet; and at the mouth of *Salters' lode sluice* the depth was only six feet, the deep channel running on the east side; and under *Downham bridge* there was above twenty feet water.

At *Stow bridge* the depth was about fifteen feet and an half, with a variety of smaller intermediate depths from *Downham bridge*, of six, eight, ten, and twelve feet.

From *Stow bridge* to *Magdalen bridge* from fifteen to twenty feet, with a variety of smaller intermediate depths, from nine to twelve, fourteen, sixteen feet, and

From *Magdalen* to *Germans bridge* from twenty to sixteen feet, and in approaching *Germans* thirteen feet, under the *bridge* twenty-five feet, and below the bridge thirteen feet.

From *Germans* to *Eau Brink*, the depth from thirteen to about nine feet, and from thence to where the great obstruction lies near *Isslington*, the depth diminishes from nine to a little above four feet; from thence to *Lynn* the soundings are very uncertain, in some places deep holes, in others so shallow that there is not above three

or four feet water to be met with, and the depths almost continually altering.

As to the falls, they have been before stated, and compared with those stated by Mr. *Golborne*, and that comparison is submitted to the consideration and decision of the impartial readers.

From *Denver sluice* to *Germans bridge*, I make the fall to be about five feet six inches, and the distance about nine miles and three furlongs; and the fall from *Germans* to *Lynn* I make to be about seven feet nine inches, and the distance to be about six miles and seven furlongs, according to the course of the river; making in the whole from *Denver sluice* to *Lynn*, a fall of about thirteen feet three inches, and the distance, according to the course of the river, about sixteen miles and a quarter. What Mr. *Golborne* and Mr. *Kinderly* state it at, and what I have made it to be at different times, and in different courses of my levels will appear in the preceding pages.

I shall now endeavour to state the quantity of the obstruction arising from the impediment or bank of sand lying near *Islington*, as before mentioned; which I thus consider. It begins with nothing at *Islington*, it increases to a depth of about five feet at *Germans*, about fourteen feet at *Magdalen*, about six feet at *Stow*, about one foot at *Downham*, and comes to nothing again at *Salter's lode*; all which depths together make an average of about four feet from *Islington* to *Salter's lode*. Such a column may reasonably be expected to be taken
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away by the removal of that obstruction, and it may be supposed, the water would be lowered about four feet at *Denver sluice*, agreeable to Mr. *Golborne's* opinion. It is therefore necessary, in order to obtain a more perfect drainage, that that bank and all such like obstructions in the course of the present channel should be removed, either by the increase of the power of the *ebbs*, by admitting the tides into their ancient remote and capacious receptacles, which they formerly were received into, or by providing some new passage for the waters through a channel *free* from those obstructions. The latter was formerly proposed by Mr. *Kinderly* and others, and is now adopted and warmly recommended by Mr. *Golborne*, in his report before mentioned; and he forms very sanguine hopes of extraordinary benefits to be derived from it, and in page 6th, says,

In order therefore to give the *utmost* relief to these levels, it will be necessary to cut a new channel through the marshes, two miles and three quarters long, from *Eau Brink* to half a mile above *Lynn*, to form a bank on each side of it with proper forelands, and to turn the river down this channel, by a dam made over the old river.

In this description of the work proposed, Mr. *Golborne* has not given the dimensions of the channel proposed to be cut, the height of the banks, nor the breadth of the forelands. For this being a work previously proposed and taken under consideration before Mr. *Golborne* was

was applied to, those particulars were before stated, and if I am rightly informed, the cut was to be made two hundred feet in breadth at the top, and ten feet in depth, with banks on each side, one hundred feet in the seat, forty feet at the top, and ten feet high, and forelands on each side of one hundred and twenty feet in breadth, and the expence was estimated at about six thousand pounds.

Some time since, this scheme was professedly adopted by the *honourable Corporation of Bedford level*, but for some reasons it was thought to be declined, till from Mr. *Golborne's* view, it was by him so strongly recommended, that it is now taken up again.

The advantages Mr. *Golborne* expects from it, are no less than giving the *utmost* relief to the *levels*; for says he, “there being a fall of four feet nine inches, in that distance, the current will run with great velocity, and soon grind down a deep channel; and the river upward being already very deep, the surface of the low water will be lowered at least four feet at *Salters' lode*, *Denver sluice*, and at the mouth of the *New Bedford* river. This cannot fail to give immediate relief to both these levels, and these four feet will be instantly felt in *Middle fen*, *Ramsley*, and in *Whittlesey*. The surface of low water, being lowered four feet at the lower end of the *New Bedford river*, the velocity of the current in the *Ouse* will be so increased, as to grind down the bottom to a proper depth. The river, by the map,

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“ is twenty miles long, and a fall of nine feet
 “ in that space ; and admitting the current to
 “ have an inclination of three inches in a mile,
 “ the surface of the water would be lowered
 “ four feet, which being added to four feet
 “ brought up from *Eau brink*, makes eight
 “ feet ; so much then would the surface of the
 “ water be lowered at *Earith*, and would run
 “ more than nine feet under soil. The banks
 “ from the *Hermitage* to *Swansey*, which is the
 “ barrier of the *South level*, would no longer be
 “ in danger ; and the spring tides which now
 “ only reach *Sutton-gault-bridge*, would then
 “ flow beyond *Earith*.

And says he, “ it is to be considered, that
 “ by thus deepening the channel of the *New*
 “ *Bedford river*, an additional column of wa-
 “ ter, near forty miles in length of the breadth
 “ of the river, eight feet deep at the *upper* end,
 “ would have its course through it twice in
 “ twenty-four hours, and coming down in the
 “ last quarter’s ebb, when the stream is so lan-
 “ guid, would assist much in scouring and deep-
 “ ening the channel.”

This last is a matter that has been before
 considered, and properly examined, to which
 I must refer the reader ; and in the preceeding
 part there are two things to be attended to.

The first is, the lowering the low water-
 mark four feet at *Salter’s Lode*.

The second is, the effects which that cir-
 cumstance is expected to produce.

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In respect to the first, it has been observed, that a body of water about equal to a column of four feet in depth being stopped up between *Islington* and *Denver sluice*, by the obstructions in the *Old channel*; by the opening of a *New channel* free from those obstructions, the water must of course be lowered about four feet, all the way up to *Salter's Lode* and *Denver sluice*, merely from the freedom of its passage, and being turned away from the obstructions which hindered it, without any advantage from an increase of its fall, for that is impossible; the fall between any two points of an inclined plane being the same, let the courses from one to the other be ever so different. Nor is there any advantage in respect to velocity, (as is most generally, though erroneously apprehended); *for all bodies descending on inclined planes of ever so different lengths, and equal perpendicular altitudes, at the end of their falls, and in every proportional part of it of equal perpendicular altitudes, acquire exactly equal velocities, setting aside friction, or any other accidental obstructions which may prevent it.* The advantage of a shorter course, in conveying water, or any other bodies, from the same two different points in an inclined plane, is not in velocity, but in *time*, the distance being shorter, with the same velocity they are brought from the upper point to the lower in a *less time*; therefore a greater quantity of water will be discharged through the shorter passage than through the longer in the *same time*, between
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the same two different points. The velocity of the current, therefore, will be no more increased in coming through the *new cut*, than in coming through the *old*, in case all obstructions were removed in the *old one*; but yet the power of grinding or scouring would be increased in the *new one* more than in the *old one*, by reason of the *greater* quantity of water running through it in the same time, by the shortness of its passage. The reduction of the low water-mark at Denver sluice is by no means to be imputed to any increase of fall, which will be obtained by the *new cut* proposed, but only to the *freedom* obtained for the descent of the waters, by avoiding the *obstructions* in the *old channel*.

It now remains to consider, what Mr. Golborne says will be the effects of the reduction of the low water-mark four feet at *Denver sluice*.

And first he says, it cannot fail to give immediate relief to both these levels, and these four feet will be instantly felt in *Middle fen*, in *Ramsay*, and in *Whittlesey*. But he gives no reason for this effect; but only asserts it will happen from the cause he has assigned, but from what known and established laws, or what principles in nature, it should happen, he has not thought proper to explain.

That every cause will produce its natural and proper effect, unless hindered by some other superior cause, is a maxim, I believe, pretty generally established; and so far as the reducing
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of the low water-mark four feet at *Denver sluice* may be considered as a cause, it must affect both the influx and reflux of tides, and the descent of the freshes in the river, from *Lynn* to *Denver sluice*, and from *Denver sluice* through the *New Bedford river* to *Earith*. In respect to the *South level*, as *Denver sluice* is now standing, which prevents the tides from flowing into that level, it can only be affected by the increase or decrease of the *free descent* of the waters in it, or coming through it; and that the want of capacity in the water-ways of the present *sluice* is a considerable impediment to the free descent of the waters out of that level, Mr. *Golborne*, himself, acknowledges. In page 12, of his report, he says, "Having taken the dimensions of *Denver sluice*, I am of opinion, that in the present state of the river, it is not sufficient for discharging the waters in time of floods;" but does not explain how the *South level* will be affected by the reduction of the low water-mark, any further than what he had before asserted; and only says, its capacity will be enlarged, by the recovery of the outfall. He would by no means recommend any alteration to be made in it, until the effects of that salutary measure have been tried; and he says, if that be found deficient, an addition may easily be made to answer all the purposes of navigation and drainage. If so, that would be *brave indeed!* But why would Mr. *Golborne* delay it, as he acknowledges, all temporary expedients are attended with prejudicial

dicial effects in the end ; or, indeed, how can he suppose it possible ever to become *necessary* ; as he says, in order to obtain the *utmost relief* to these *levels*, a new cut must be made through the *marshes*. After the *utmost relief* is obtained, sure there can be nothing *further* wanting ; but having spoken of this before, I shall now consider what relief, in the present condition the *South level* is in, with *Denver sluice standing*, it can reasonably be expected to receive, from the reduction of the low water-mark at that *sluice*, four feet lower than it now is.

It has been before observed, that the present water-ways are not sufficient to discharge the waters in the time of floods ; and it is evident that they are not. The low water channel above them ordinarily is about one hundred and fifty feet, and in time of floods, near two hundred feet in breadth, and the clear water-ways in the sluice taken altogether, make a breadth of only about ninety five feet.

All the effect, which the reduction of the low water-mark four feet at *Denver sluice*, could have upon the waters of the *South level*, would be the addition of four feet to their present fall, (supposing that the sluice did not stand in the way) and that would proportionably accelerate the descent of the waters. If the level was properly *imbanked*, and *Denver sluice* taken out of the way, as the level would be then secured from the overflowing of the upland waters, the additional acceleration, obtained by

such an increase of the fall, would be a great advantage to the discharge of them; as about one fifth part more water would be discharged in the same time, and one sixth part of the rise of the water would be prevented, and the operative power of scouring would be proportionably increased. According to my levels, the fall from Ely bridge to Denver sluice was about six feet, if an additional fall of four feet was added, it would be ten feet; and the square root of six is to the square root of ten, nearly as the number twenty-five to the number thirty-one; the latter of which is about one fifth part greater than the former, and so much in proportion would the velocity of the water be increased, in a distance of about eighteen miles. If the *level* was imbanked, as there would then be only the *downfall* waters to be carried off, after the subsiding of the *land-floods*; if no obstruction stood in the way, it would certainly receive great relief from such an addition to the fall. But even then, in an unimbanked state, such as it now is in, it could not be expected, without the rivers were very *deep* indeed, that the land-floods descending with the rapidity, which sudden and hasty downfalls of rain occasion, (especially since many better passages are made above for their more ready conveyance), could be carried off without *overflowing* the lands. When once overflowed, the grass and other strong weeds, which those lands are productive of, would soon grow up in the water, through which, in its endeavour to descend,

descend, it is strained, as as it were through a cloth, and cannot receive the benefit of its fall. These would be the effects of such an additional fall, in respect to the descent of the fresh waters, in case the rivers were *open*, and no such a structure as *Denver sluice* stood in the way; but as that is now standing, the case will be very different, and the benefit of the fall will be greatly abated. It is to be considered, that at the first approach of the flood tide the *doors* of the *sluice* will be shut; and the passage of the waters of the *South level* will be stopped, not only during the whole time of the flowing of the tide, but for a great part of the time of its *ebbing*, until it falls to a level with the waters on the upper side of the *sluice* in the *South level*; during which time, the fall of those waters will be continually diminished, and in the whole time of their stoppage, they are now raised about *three feet*. If by the new cut proposed, the tide should be brought up sooner, and flow longer, which is one circumstance expected from it, the waters of the *South level* will be then so much the longer stopped in, and will rise so much the higher above the sluice. Let it then be supposed to rise about four feet; if the tide at the *sluice* should rise twelve feet, as may be expected, to correspond with Mr. *Golborne's* observations, it must ebb *eight feet*, before the waters of the *South level* could descend at all; in which time they would rise to about the present standard of the low water-mark, and therefore little, or no benefit,

nefit, would be received from it, till the latter part of the *ebb*, and the whole advantage will not be received until the time of *low water*. It is, therefore, very evident, that an increase of fall which cannot take place until the very *latter part* of the *ebb*, and which gradually increases only from that time to the time of *low water*, must be so far from giving the utmost relief to that *level*, that it would scarcely give it *any* at all. Such an additional fall operating in so gradual a manner, and for so short a space of time, at fourteen or sixteen miles distance from the *Middle fen*, where a surface of sixteen thousand acres is so covered with water, as to be abandoned and given up, as beyond the power of *mills* to recover, must be so far from being *instantly* felt, that it certainly would not be sensibly perceived. Besides, by the contracted passage through the water ways in the sluice, the effect of the fall would be considerably diminished, and the velocity of the waters descending through the *South level*, would be so much inferior to the velocity of the ebbs and freshes descending through the *New Bedford river*, that the water in the former would not subside so fast as in the latter. This would occasion a *cataraet* from the one to the other, which will be proportionably great according to the difference of the velocities of the water *above* and *below* the sluice.

Having now considered Mr. *Golborne's* plan in respect to the *south level*, I shall more particularly

cularly attend to what he says upon the *New Bedford river*.

That the low water-mark at its mouth, will be reduced four feet lower, which additional fall will make an increase of the velocity of the descending waters, and in a proportional degree, lower them in that river, has been before concluded, and the quantity of those effects has been estimated. It has been shewn, that unless the bottom of that river was lowered by manual labour in a particular manner, it would be impossible for it to receive a column of tide water of *eight feet* in depth at the upper end. That such an increase in the velocity, as the reduction of the low water-mark, four feet at its mouth only, could not produce such an effect, will appear by considering, that though, the velocity and power of grinding will be considerably increased, yet the greatest effects of it will be in the lower parts, and will be proportionably less in the upper; therefore the fall will not be abated, but must be *increased* by it. For what reason Mr. Golborne supposes it will be *abated*, I must confess, is beyond my comprehension. It is now nine feet in the distance of about twenty miles, at the rate of near five inches and an half in a mile; and by an additional fall of four feet, the whole fall will be increased to thirteen feet, which makes a proportion of about *eight inches* in a *mile*. How Mr. Golborne can reason from a supposition of an inclination of *three inches* in a *mile*, which only makes five feet in the whole, without previously

previously lowering the bottom of the river by some artificial means which he does not mention, is quite inconceivable to me.

If, upon the reduction of the low water-mark four feet at its mouth, the bottom was all the way lowered the *same*, the surface of the water at *Earith*, would likewise be lowered *four feet*. In June, 1776, at the time of my taking the levels, the surface of the water was about two feet and an half under soil, and the depth of the water a little below Earith bridge, was about four feet; but the average depth, for about a mile, or mile and an half below, was about seven feet and an half. The surface of the water would then be reduced about six feet and an half under soil, the depth would remain the same, and the same fall of *nine feet* would be preserved; the land floods would have a deeper channel to bring them down, and would rise so much the *lesser* height against the *banks*, and consequently the *south level* would be better secured. As to its *drainage*, that, by the superior quantity of water brought down, above what would be brought down by the *old river*, in the same time, the sluice doors would be in like manner as before, kept shut, and the drainage of that level interrupted, which, I apprehend, will always be the case, so long as the waters of the *great Ouse* are brought down through the *New Bedford river*; therefore, all money expended upon it, in my opinion, would be improperly applied. The better way would be, either to turn them into
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their *old natural course*, after it is properly im-banked; or to find some other passage for them, where that pernicious effect might be avoided.

If, after the reduction of the low water-mark four feet at the mouth of the New Bedford river, the water was to flow thirteen feet there, and the bottom was so lowered, by a gradual increase from its mouth upward, so as to be sunk eight feet lower at *Earith*, than it now is, there would then remain a fall of *five feet*, in the distance of twenty miles, which is in a proportion of *three inches* in a *mile*, as Mr. Golborne states it. Then according to the state of the water when I took the *levels*, its surface would be reduced in that part of the river, about ten feet and an half *under soil*; and a column of tide water of about eight feet deep at the top, and about thirteen feet deep at the mouth; twenty miles in length, and of the breadth of the river, which I suppose to be one hundred feet, would be received into it twice in twenty-four hours. If the influx and reflux are both considered, then the quantity going through the channel will be doubled, and it will be as Mr. *Golborne* states it, viz. There will be a column of near forty miles in length, of the breadth of the river, eight feet deep at the upper end, and about thirteen feet deep at the lower end, which would have its course through it, twice in twenty four hours; which is equal to a column of ten feet and an half in depth, upon an average; one hundred feet in breadth, and forty miles in length.

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Before I further consider the effects of the tides, I shall attend a little to the descent of the freshes; as the fall would then be *less* by four feet, than it now is, the descending velocity of the *land floods* would be *diminished*; the river would be kept fuller, the water would rise higher against the *banks*, the *south level* would be more endangered, and the floods longer in getting to sea; and the descent of the waters in that *level*, would be as much interrupted, as they have been, or now are.

I shall now consider, what the effect of the new cut, proposed to be made, may reasonably be expected to be, with respect to the *outfall*.

By shortening the passage of the tide between *Lynn* and *Germans bridge*, it certainly will arrive there so much the sooner, even supposing its velocity was not accelerated. An extended body of water in motion, being directed into a narrow channel, its velocity will be proportionably increased; therefore it is reasonable to admit, that the velocity of the water in passing through this *new channel*, will be in some degree increased. This will also shorten the time of its arrival there, as also at *Denver sluice*; therefore it will arrive at its greatest height there, in a shorter time than it does in its present course. The acclivity being the same, and the impulsive force the same, only so far as the water, in a large and expanded *section*, may have its velocity increased, by being brought into a *narrower* and smaller one; at its entrance into the *new cut*, it will rise only so much above

above the horizontal level at *Denver sluice*, as its velocity is increased by the aforesaid means.

Mr. *Golborne* observed, that a tide, which flowed fifteen feet eleven inches at *Lynn*, flowed seven feet nine inches at *Denver sluice*. In October, 1776, it appeared, by observations then made, the same tide which flowed seventeen feet three inches at *Lynn*, flowed eight feet nine inches at *Denver sluice*. It may therefore be concluded, that a tide which rises about seventeen feet at *Lynn*, would now rise about eight feet at *Denver sluice*, and when the low water mark there was reduced four feet lower, such a tide would then rise about twelve feet. By allowing for the increase of velocity at entering the *new cut*, it may be supposed, that such a tide would rise about thirteen feet at *Denver sluice*; and would throw into the *New Bedford river*, properly deepened, such a column of water as before mentioned. If the new cut be made two hundred feet wide, and the distance from *Lynn* to *Eau Brink* be two miles and three quarters, and the breadth of the river, from thence to *Germans bridge*, be two hundred and fifty feet, and the distance about one mile and three furlongs; and the breadth from *Germans bridge* to *Denver sluice* be taken upon an average, at about one hundred and sixty feet, and the distance about nine miles and an half; the average breadth of the river, from the entrance of the new cut at *Lynn* to *Denver sluice*, taking the different distances into consideration, will be about *one hundred and*

and seventy seven feet. The whole distance will be about *thirteen miles* and *five furlongs*; and a tide which flows about seventeen feet at *Lynn*, and thirteen feet at *Denver sluice*, will flow upon an average, through the whole distance, about *fifteen feet*. The quantity of water received into that part of the river every tide, will be equal to a column of water of fifteen feet in depth, one hundred and seventy seven feet in breadth, and thirteen miles and five furlongs in length. In its influx and reflux, it would be equal to a column of double that length, viz. A column of fifteen feet in depth, one hundred and seventy seven feet in breadth, and twenty seven miles and a quarter in length, and this added to the water received in the *New Bedford river* before mentioned, will make a quantity of tide water equal to a column of about twelve feet in depth, one hundred and thirty one feet in breadth, and sixty seven miles and a quarter in length; which in its influx and reflux, will have its course *through Lynn haven* and *channel* twice in twenty four hours. As the power of scouring and grinding depends upon the motion of the water, whether it goes upwards or downwards, so long as it is sufficient to roll and keep the soil it had before raised, suspended, without suffering it to subside, it will not *injure* a channel. But when its motion is so abated or diminished, as not to keep the soil it had raised, *rolling* or *suspended*, but suffers it to subside, it will then have a tendency to *choak up* and *in-*
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jure a channel, let the motion be either upward or downward. This shews the great impropriety of setting up *sluices* or making dams across channels, especially in the way of *strong tides*; for the greater the force of the water is, the more *soil* it will raise and roll along with it; so the more that motion is diminished, the more of its soil it will *drop*, and where it is entirely stopped, all the soil *rolled up*, or of any considerable ponderosity, must be immediately stopped, and let down. In a little time all the finer and lighter sort, kept suspended by the motion of the water, will by degrees subside, and *there* either the whole or part will lie at *rest*, unless a force of water, *equal* to that which brought *it up* acts upon it again.

From hence it is easy to conceive how pernicious the setting down of *Denver sluice* in so strong a *tide way*, and the diminishing the quantity of the *ebbs* above it, must have been to the channel *below it*.

It may be remarked, that the influx of the tides cannot promote, but must obstruct *drainage*; *temporarily* they certainly *do so*—but if they improve the channels and outfalls through which the freshes are to descend, as they do both in their influx and reflux, they are in that respect advantageous to *drainage*. Without an outfall the freshes could never get to *sea*, and being absolutely stopped, must inundate and overflow all such lands as they could spread over, and there lie for ever stagnated.

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In the flux and reflux there is something particular; the motion of the water is twice changed every tide, *viz.* from the *reflux* to the *influx*, and from the *influx* to the *reflux* again; these changes not only make an abatement, but for a short time occasion an absolute stoppage of their motions, and in the influx, the water being more loaded with soil, at the time of the stoppage, than it is in the reflux, especially in spring tides, the effects of that stoppage in those places which the tides leave, before the ebbs and freshes acquire a proper velocity are very conspicuous. The quantity of soil dropped by the stoppage and diminution of their motions becomes very remarkable, and many people are apt to draw an inference from it, that the admission of the tides must, in general, be *prejudicial* to channels, and tend to the filting and choaking them *up*.

It must be considered, that these effects are entirely owing to the diminution and *stoppage* of their motions, and the bad effects of them can take place only, where the force of the ebbs are not sufficient to repair the *injury*; such as on the margins of rivers and shores, which the tides do not cover till near the time of high water, and which they leave before the ebbs can obtain any considerable force, for want of an *increase* of their falls. In the main part of a channel, through which the largest body of the tides flow and reflow, it is otherwise; the decrease of the velocity of the tides is somewhat gradual, but not of long continuance, and the entire stoppage is almost momentary.

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These things happen in the lower parts of a channel first, before they take place in the upper parts; by these means, when their descent takes place, they follow with a *greater* degree of velocity, through the *lower* sections than the *upper*; and, therefore, roll out *more* soil than they bring *into* them, and take away the soil left in them by the abatement of the motion of the tides. Upon this principle, the *tides* and *ebbs*, without any assistance from the *freshes*, might be able to maintain and improve the *lower* parts of a channel; but the *upper* parts, at the extremity of the flowing, where there were no *freshes* to act upon the soil there dropped, it would be continually choaking and *growing up*. Where a body of descending *freshes* are united with the *ebbs*, the power of the water will not only be greatly increased in scouring the *lower* parts of the channel, but the choaking up of the *upper* parts will be thereby prevented. The *ebbs* and the *freshes* will act with united force; and the power of the *freshes* will be every fortnight increased by the increase of the *ebbs* in the spring tides, in the same manner as they would be by the return of *land floods* in every such period of time; which sufficiently shews the great advantage in preserving and improving the lower parts of the channel, and maintaining a good *outfall*, by a *free* and *copious* admission of the *tides*. This is a principle in which I entirely agree with Mr. Golborne, it only remains, to consider whether the receptacles, which he has proposed

posed, will be sufficient for the preservation and improvement of the harbour and outfall at *Lynn*, and whether they will, by means of the *new cut* proposed, be more fit for that purpose, than the giving the tides admittance into their ancient receptacles through the *old channel*.

I have shewn before, that by means of the *New cut* proposed to be made, and the alterations in the *New Bedford river*, necessary to receive such a column of tide water, as Mr. *Golborne* represents, there will be a quantity of tide water equal to a column of about twelve feet in depth, one hundred and thirty-one feet in breadth, and sixty-seven miles and a quarter in length, which will have a course through the *harbour* of *Lynn* twice in twenty-four hours, taking the *influx* and *reflux* together. Though I have shewn that the tides in their influx, as well as their reflux, may grind, scour, and improve a channel; yet, as it is generally conceived, that it is the *ebbs* and *freshes* which principally contribute to these *purposes*, I shall only state the quantity of the *ebbs*, which according to the foregoing plan, will have their course through *Lynn harbour* and the *channel*, below the *town*, twice in twenty-four hours. This will be half the quantity above stated, and will form a column of water of about twelve feet in depth, one hundred and thirty-one in breadth, and about thirty-three miles and an half long.

The harbour of *Lynn* may be stated at about a furlong, or two hundred and twenty yards
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in breadth, upon an average. Now it may reasonably be supposed, that about a sixth part of the quantity (that is about two feet in depth of the aforesaid column) will pass through the harbour, whilst the water is expanded in nearly the whole breadth of the channel, before it is reduced to the compass of the low water passage, which may be about one third of the breadth of the whole, *viz.* about two hundred and twenty feet wide. If the remaining five-sixths of the aforesaid column, which will be about ten feet in depth, and one hundred and thirty-one feet in breadth, be reduced to two hundred and twenty feet in breadth, the length will be proportionably lessened to twenty *miles*, which will be the column equal to the quantity of the *ebb*, which will pass through the low water channel of two hundred and twenty feet in breadth, and ten feet in depth, twice in twenty-four hours. If it runs at the rate of four miles an hour, upon an average, all that water, or a quantity equal to it, will pass through the harbour in about *five hours*. According to the present time of the tides flowing, there would be about three hours for the descent of the *freshes*; and this would make it not much different from what the state of the harbour upon an average now is; the depth being mostly ten or *twelve feet*, except in some particular places in which there is not more than four, five, or seven feet, to be met with. It cannot be supposed, that in such an expanded channel, into which the wa-

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ter will flow from one so much narrower, as the *New cut* is proposed to be made, that it will keep to one certain passage, without dividing into some others, as it does in some measure at *present*. Thus its depth will be reduced, its power weakened; and according to the different force with which it acts upon different parts of the channel, and according to the different nature of the soil it acts upon, some places it will scour *deep*. The soil being driven out of such places will subside, where the water acts with less force, and there form *banks*; and the state of the channel through the *harbour* will be much the *same* as it is at present. Nor will the state of the channel below it be any more benefited; for as that part of the channel expands to half a mile or more in breadth, the depth of the water in passing through it will be proportionably diminished; and what would have made a depth of about ten feet in a confine channel of about two hundred and twenty feet wide, would there make a depth of only about one foot.

From this, it appears, that the quantity of the tide water carried up above *Lynn harbour*, by means of the *New cut* proposed, and the receptacles of the *New Bedford river* intended to be provided for it, will not return an *ebb* sufficient to make any *improvement* in *Lynn harbour*, the *channel*, or the *outfall*; if, therefore, the improvement of the *outfall* is necessary to the recovery of the *levels*, it does not appear probable, that the plan now proposed will ef-
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fect it. It is pretty evident that larger receptacles for the tide waters must be procured, than what Mr. Golborne has assigned for them, before such a desirable, such a beneficial effect, both to *drainage* and *navigation*, can be procured. Though it is very clear to me, that so long as the *South level* continues *unimbanked*, and *Denver sluice* is suffered to hinder the free descent of the waters of that *level*, and the land floods in the *Great Ouse* are brought down in a channel so improperly situated as the *New Bedford river* is, that the improvement of the *outfall* would afford very *little* relief to that *level*.

In respect to the improvement and recovery of the *outfall*, it may, perhaps, be immaterial, whether the receptacles for the tides be in the *South level*, or the *New Bedford river*; provided that they are large enough to receive a sufficient quantity of water to scour out the *sand beds*, which for want of a proper power and force in the *ebbs* have since the erection of *Denver sluice* been raised, and now continue to *lie in it*. I say, respecting the *outfall*, it may be immaterial, whether such a quantity is received into the *South level*, or into the *New Bedford river*. Upon other considerations there may be a considerable difference; by being received into the rivers in the *South level*, the navigation in all those rivers would be much *improved*, by the reflux through them; their channels would, if properly *imbanked*, be continually *deepened*, the *land floods* would be sooner

carried off, and the level would sooner be *re-
lieved* and entirely *secured*.

I shall now compare the quantity of the tide water, anciently flowing up into the receptacles above *Lynn*, which, before the erection of *Denver sluice*, used to have its course through that *harbour*, and the *channel* between it and the *sea*, twice in twenty-four hours; with what has before been shewn to be the quantity, which would have the like course in the same time by the *plan* now proposed.

The channel between *Lynn* and *Germans* was then in many places a *mile wide*, and *deep* as well as *broad*; and the tide flowed about five hours at *Lynn*, and filled the rivers, and all the ancient receptacles before mentioned. The quantity of water received into which, has been shewn to be greater, than what will be received into the *New Bedford river* by the plan now proposed; and was stated to be equal to a column of water of seventy-seven feet in breadth, seven feet in depth, and forty-four miles in length; which is about equal to a column of ten feet in depth, one hundred feet in breadth, and twenty-three miles and an half in length; viz. about one eighth part more than the *New Bedford river* would receive, by a column of eight feet in depth at the upper end, and thirteen feet deep at the lower.

The breadth of the river from *Lynn* to *Eau
brink*, before the building of *Denver sluice*, may be stated at half a mile, on an average; and the distance at about five miles and a half.
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The breadth from *Eau brink* to *Germans bridge* is about two hundred and fifty feet, and the distance about one mile and three furlongs. The breadth of the river from *Germans bridge* to *Denver sluice* may be stated at one hundred and sixty feet, and the distance nine miles and about three furlongs; all which different breadths and distances taken into consideration, make an average breadth of about one thousand and seven feet, from *Lynn* to *Denver sluice*; the whole distance being about sixteen miles and a quarter. A tide, which rises seventeen feet at *Lynn*, and thirteen feet at *Denver sluice*, will make the average flow fifteen feet; which will make the quantity of tide water, which flowed every tide between *Lynn* and *Denver sluice* equal to a column of fifteen feet in depth, one thousand and seven feet in breadth, and about sixteen miles and a quarter in length. This added to the aforesaid quantity put into the receptacles above *Denver sluice* before the tides were stopped out by it, will make a quantity of tide water received into the rivers above *Lynn*, and the quantity of *ebb* water returned through the harbour of *Lynn* twice in twenty-four hours, equal to a column of about twelve feet in depth, four hundred and seventy-one feet in breadth, and thirty-nine miles and three quarters, or in a round number it may be said, forty miles in length; which is more than four times as much as the *New cut* proposed to be made, and the *New Bedford river*

river, formed according to Mr. *Golborne's* plan, will afford.

If one fourth of the quantity of the tide received between *Lynn* and *Germans bridge* be ebbd out, before the ebb at *Lynn*, has uncovered any of the sands, there will then remain to follow, a column of water of sixteen feet in depth, of half the width of the harbour, viz. one hundred and ten yards in breadth, and about thirty-one miles in length, which, at the rate of five miles per hour, would be about six hours in passing through the harbour, expanded to half the breadth. If by the uncovering of the sand banks the water was more contracted, into one third of the breadth of the whole, it would maintain a channel of the same depth, and must run with a velocity of more than seven miles an hour, to pass off in the same time. It cannot be matter of wonder, to hear from *history*, that before the building of *Denver sluice*, viz. in the year 1645. *The river at Lynn was in breadth about a furlong, and the ships both that, and several years after, rode at anchor at the South end of the town, and on the west side of the river, in two fathom at low water; having then such strong tides, that they were often forced to moor with a stream cable, which was one extraordinary, to hold them fast.* (See *Badelade's hist.* p. 60).

Such powerful bodies of water, which had then their courses through the *river Ouse, Lynn barbour*, and the *channel to sea*, must have been able to maintain always some principal, main, and

and deep *channel*, through all the banks of sand which lay in their way. Indeed by some accidents the course of the water might be altered, an *old* channel might be deserted, and a *new* one created, but some *principal channel* would always be maintained, so long as there was a sufficient body of water to preserve it. When the body of water became diminished to a less quantity, and could not maintain some principal *channel*, the resistance it met with in every direction, which it was not able to overcome, divided it into a multitude of courses, and destroyed the little force it was empowered with.

From these circumstances, and the violent agitations which expanded surfaces of water are liable to, by the impetuous action of winds and storms, it evidently appears, that in many cases confined and properly imbanked channels have their preference with respect to drainage, especially, if they could be continued to the outfall, and could deliver their descending waters immediately into the deep *ocean*. Where a narrow and more confined channel discharges its waters, into a much more expanded and *wider* one, through which they must pass to the *outfall*, if the quantity brought down by such a strait channel is not sufficient to force its way through the *sand beds*, and such impediments as it may meet with in that *wider* part of the channel, the *outfall* must come into *decay*, and the drainage be *obstructed*. In some such cases *navigation* may require more than
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may be absolutely necessary for *drainage*; for where there is an extensive maritime *traffic* carried on by a great number of *large vessels*, made use of for exports and imports, as there is at *Lynn*, a capacious *harbour* is required for their *reception*, and a *wide* as well as a deep *channel* to and from the sea. Not only, that they may not be incommoded by the number passing, but that in case of *contrary winds* they may make their passages up and down by the use of their *sails*, in that manner which the sailors call *turning to windward*, and without which convenience they would be often interrupted and stopped for want of a *fair* wind. Though a capacious channel may not be so necessary for *drainage* it is very requisite for the purposes of a large maritime *traffic*; and such large and capacious channels can never be maintained *deep*, without large and extensive receptacles for the tide waters *above* them, to return powerful bodies of *ebbs* united with the *fresbes* through them. Confined channels have their advantages, by keeping the waters more *united*, and their forces more *collected*; yet, if they are not made large enough to admit and return a sufficient quantity of *tide water*, so as produce *ebbs*, which, in conjunction with the ordinary course of the *fresbes*, may be sufficiently powerful to maintain a *deep* channel through the wide *harbour*, which they must pals to the *outfall*, no benefit either to *drainage* or *navigation* can be received from them.

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With respect to the advantages to *navigation*, which Mr. *Golborne* enumerates, and expects from the new cut proposed; it must be allowed, that deductions drawn from experience are to be looked upon as more conclusive than bare conjecture; and the opportunity I have had of making observations on the effects of the new cut, made under my direction, through the marshes and sands below *Wisbeach*, will in some measure enable me to deduce the effects, which may reasonably be expected from the new cut intended.

The dimensions of that new cut being very small in proportion to the channel, which the tides filled below it, when they were wholly turned through it, they ran with such an impetuous force and rapidity, that the *barges* which they navigate with in that *river*, (which are much larger, and being single, are much more readily managed than the trains of smaller boats made use of in the rivers above *Lynn*,) were hurried through in such a random manner, as not to be capable of being steered, or managed in any order; and when offered to be stopped by their anchors, their cables were snapped like packthread. The quantity of sand rolled through it, formed such beds in the wider channel above it, that in some places there was scarcely any passage left for the barges; and several of them being driven upon those sand beds in the latter part of the spring tides, were obliged to lie until the return of the next spring, before they could proceed

ceed up to Wisbeach ; until a land flood happening, returned the soil through the new cut, cleared that part of the river of the sand beds, and opening a free passage for the spring tides, they flowed higher up the river, and by an increase of the ebbs, the channel has not only been preserved, but much improved.

From these circumstances it may reasonably be inferred, that as the tide comes in stronger at *Lynn*, and rises higher than in the upper part of the channel below *Wisbeach*, the tide waters filling so large a basin as *Lynn harbour*, and endeavouring to continue their whole motion, a great part, by the openness of the new channel, being directed towards it, will, (by the smallness of its dimensions,) be compressed into it, and impelled through it with so great a rapidity, especially in spring tides, that the trains of small boats they navigate with in that river, either with or without horses, will be entirely unmanageable, will run foul, or break from one another, swing across the river, be frequently upset and sunk; and they will for some time be obliged to wait the approach of high water, that the rapidity of the current may be abated before they obtain a safe passage through it; consequently it will be so far from being at all times a ready passage, that great and constant delays may be expected from it, and how long they may continue is not easy to determine. And beside the disadvantages to *navigation* by the interruption of passage, there are other effects which may be reasonably apprehended

prehended from it, so long as *Denver sluice* is left standing.

The acceleration of the motion of a great part of the tide water in *Lynn haven* tending towards the *new cut*, and the rapidity of the current through it, will carry large quantities of silt into the upper parts of the river, which will plentifully subside in those parts of the channel, which are now the deepest, and will soon fill them up to a level with the more shallow parts. As only a part of the water carried up to *Denver sluice* will be received into the *New Bedford river*, and the rest will be stopped by it, the whole time of the flowing of the tide, as it is now and always has been since it was erected, the water by the rapidity of the current below being more copiously stocked with silt, the greater quantity will subside. The river in that part will begin to choke up again, which will by degrees increase; and unless that pernicious obstruction, *Denver sluice* be removed, and a free passage opened for the whole body of the tide water to strengthen the power of the ebbs, the silting up of the channel as formerly may reasonably be expected, though, perhaps, not in the same degree.

In vain, therefore, are the expectations of great advantages to the navigation from the *new cut* whilst *Denver sluice* is standing; and in vain are the hopes of a perfect recovery and a full improvement of the *fens*, until the *levels* are properly and sufficiently *imbanked*.

That the new cut now proposed, and the receptacle for the tides intended to be substituted in lieu of the more capacious and remote ones, they formerly were received into, will not be sufficient for the improvement of the *outfall*; and that these works will be so far from giving the *utmost* relief to the *South level*, that they will be of very *little*, if any *benefit* at all to it, has been before made evident.

As to the *Middle level*, so long as *Salter's lode sluice* and the *Old Bedford sluice* are kept standing and any part of that *level* remains *unimbanked*, the reduction of the low water-mark four feet lower at those places will be of small benefit to it, as by the more early flowing of the tide the doors would be the *sooner* shut, and *longer* continue so, by which means the water would rise so much higher on the *inside*, and so much more of the fall would be *destroyed*. No discharge could take place till the latter part of the *ebb*, after the water had subsided *eight feet* in the river below the *sluices*. Then the fall would come gradually on, and the whole benefit would not be felt until the very time of *low water*, when it was again about to be taken *away*; and it would be so far from giving the *utmost* relief to the *Middle level*, that its effect upon a surface of ten thousand acres of water either at *Ramsley* or *Whittlesey*, in any reasonable time, would scarcely be perceptible.

If the bottom of the *old Bedford river*, was sunk ten feet under the *soil* of the present *washes*, and made about one hundred and thirty feet

feet wide at the top, about seventy feet at the bottom, with banks on each side of about ten feet in height, with forelands of about eighty or one hundred feet in breadth, as proposed in my observations in an *Address to the Public*, and all the waters of the *Great Ouse*, (except in the time of the *land floods*, when some should be suffered to go through the *Hermitage sluice*, down the old channel to *Harrimeer*, to join the river *Grant* at that place) were turned into it, and their course down the *New Bedford river*, was entirely stopped by *Pen sluices* placed at the *ends*, for the service of navigation *only*; then by an addition of four feet to the fall of the waters passing through it, they must be much accelerated, and the *land floods* would be sooner carried off by it. From its more distant situation, the descent of the *fresh waters* from the *south level* would be much less, if at all *interrupted*; and if that drain, which is called the *forty foot*, or *Vermuyden's* drain, coming from *Whittlesey Meer* into it, was deepened to about eight feet under soil; enlarged to about eighty feet in breadth, and properly imbanked, with all other parts of the level where banks may be wanted; the *middle level* (as the Old Bedford river is properly situated for that purpose) might expect great relief by the additional fall of four feet at its mouth, acquired by the new cut proposed; and perhaps there might be no occasion for opening *Bevel's leam* into *Wisbeach river*. If the waters were freely carried down from *Peterborough*, in a
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suitable channel of proper depth, well *imbanked* on each side, that quantity might be as much, as that river and the *bridge* at *Wisbeach* could discharge, without some enlargement. As to the *New Bedford river*, it is of very little or no service to the *drainage* of either the *south* or *middle level*; and the waters of the *Great Ouse*, might have been better conveyed down the *Old Bedford*, and the *middle level* been at the same time relieved by it. It is not easy to understand what could be the inducement for expending such a large sum of money upon that work; as the *opening*, *deepening*, and *imbanking* the *Old Bedford river*, would have answered the purpose intended by it much better.

When the impropriety, the inefficacy, and the enormous expences of these works, have been experienced in a course of more than *one hundred years*, that any advocates can be found to support them, is not only a matter of surprise, but an amazing instance of the strength of prejudice.

The *south* and *middle levels* are a large tract of *low lands*, through which the waters from the springs and rains of a great extent of *high lands* had their courses, by some large natural *rivers* toward the sea; and their mouths lying open to it, the tides also made their alternæ flux and reflux into them. The power of these waters being constantly *united* in the return of the *ebbs*, the channels of those rivers were constantly wearing deep, and in a process of time, before the undertaking of a *general drainage*,
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or any artificial *banks* were made in them, they were worn so deep, that in the ordinary course of the waters, they usually run with their surface about *ten feet* under the surface of the *soil*. In the *winter time*, when the springs were copious and the rains frequent, and sometimes in in the *summer*, when great downfalls of rain suddenly happened, these rivers were *overfilled*, and the lands *inundated* by them. As the tides had their constant course of flux and reflux in those rivers, and the several branches within their reach; sometimes, when the tides flowed higher than ordinary, they would also flow over the lands, especially the lower parts. This only happening at the time of the *flood* tide, every *ebb* would draw them off, and the inconvenience they suffered by that circumstance, was the injury that the grass might receive by the saltness of the water, and subsiding of the *silt* upon the *land*; which however in time was so much *heightened* by it, as to make the injury less frequent. The land floods having a free passage to *sea*, upon the return of summer, the winter floods were carried off; and those occasioned by *hasty* rains in *summer*, laid not long upon the lands. This was the condition of the *levels* particularly of the *south level* before the general *undertaking* was entered into, as appears by the report of Sir *Clement Edmonds* before mentioned, and other testimonies to be met with in *Badeslade's history*.

To prevent these injuries, the remedies were obvious, nature pointed them out. Either the
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course of all the *high country waters*, must have been diverted and prevented from entering into the *levels*, or, if the whole, or part of them, were suffered to come through, the channel by which they passed, ought to have been sufficiently and properly imbanked. This would have *effectually* prevented the injury from the *overflowing* of the waters; and when those floods were passed off, the downfall upon the *levels*, by proper drains for them, would soon have followed them into the sea.

The first of these might perhaps be thought impracticable, and the other it seems was thought too expensive, and so neither of them was made use of, but an ineffectual expedient was adopted. Part of the waters, viz Those of the *great Ouse* were turned out of the *level*, and the tides were prevented from coming into it, by the great expence of cutting the *New Bedford* river, twenty miles in length, and the putting down the *Hermitage* and *Denver sluices*; by which means the free course of the *land floods* left to come through the *south level* to sea was much interrupted, more annoyed, and all the bad effects before recited, resulted from those *ill concerted* and ill advised works. Since that time, one fruitless expedient or another has been continually trying; vast sums of money have been expended, and the only natural, essential, and effectual remedy, the imbanking of the *levels*, has been *neglected*. I will venture to say, that if half the money had been employed in that work, which has been expended

pended in ineffectual expedients, calculated to serve partial purposes, the work might have been compleated; the levels recovered into a state of security, and cultivation and luxuriant crops of grain might have been growing, numbers of cattle feeding, and smiling *plenty* have been spread over the face of a country, where little but water and weeds, desolation and distress, have now fixed their habitation.

But bad as it is, it is not yet irremediable; kind Nature still points out the way to a recovery. Imbank the *levels*, confine the *waters*, open a free passage for the *land floods* to sea, receive the *tides* to aid the feeble freshes, give Nature her own course, and all will be retrieved; but vain it is to fight against the force of Nature. If it is suggested, that the expence will be too great for the means of raising it, or the purpose of expending it, the business ought in reason to be given *up* as irremediable; but I am well satisfied this is very far from being the true state of the case. The work properly entered upon, might gradually proceed, till all was effected, though at a large, yet not an unattainable or insupportable *expence*. The calculation of which I do not at present enter into, but the order of doing it I would recommend as follows, viz. With respect to the *South level*, imbanking is the *primary*, the necessary, the essential *work*, that should be *first* entered upon and compleated. The end and purpose of it, being to secure the level from the overflowing of the *land floods*, that work should be begun in the *upper* parts of the principal *rivers*, where those waters first

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enter the *level*; that is, in the upper part of the river *Grant*: and the work should be progressively brought downward, till that is completed. Then all the other lateral branches should follow in their proper courses; and all gravels, and such like impediments should be removed, and the rivers deepened, where it is wanted and practicable to be done, either by hand or by machines. Above all things, care should be taken to set the banks at *moderate* distances, so as to shelter the surface of the water from the force of impetuous *winds* and *storms*; and where the contiguous soil will not afford proper materials, either clunch, or silt, or both, may be brought by water at no very extravagant expence. In the compass of about three years time, all the works of imbankment necessary to be done for that *level*, might be completed; after which, either *Denver sluice* should be removed, or *Saint John's Eau* fully opened and scoured out, for the free descent of the freshes to *sea*, and the admission of the *tides*, into all the receptacles they could reach in the *upper* part of the river, and the lateral branches leading into it. The course of the water through the *New Bedford* river should be stopped by *Pen* sluices; the upper and lower mouths of the *Old Bedford river* should be laid intirely open (that all the waters of the *Great Ouse*, except in the time of *land floods*, that a part should be suffered to descend through the *Hermitage sluice*, to join the waters of the *Grant*, &c. at *Harrimeer*, by making a bridge at *Ea-rith*, and a bank from the town's end to the *New Bedford*

Bedford, as proposed in my *observations* in an *address* to the public.) The bottom should be sunk ten feet under *soil*, and the top made about one hundred and twenty or thirty feet wide, with banks and forelands as before mentioned; and the *forty foot* enlarged and deepened as before proposed. If then, the united forces of the ebbs and freshes prove not sufficient to scour out the sands, and maintain one principal and deep channel between *Eau brink* and *Lynn*, as they formerly used to do, and through *Lynn* harbour, so as to obtain a good outfall, and to reduce the low water-mark at *Salter's lode sluice*, at the mouth of the Old *Bedford* river, and at the place where *Denver sluice* now stands, four or six feet lower than it now is; then it may be requisite and necessary, to make such a *new cut* as is now proposed, (but, as I apprehend, of considerably larger dimensions,) between *Lynn* and *Eau brink*. Till the levels are properly *imbanked*, and the tides have their free admission into their ancient *receptacles*, any thing which may be done in the lower part of the channel, I am very clear, will contribute very little to the *drainage*, improvement, or security of the *South level*, so long as *Denver sluice* is standing, and the waters of the *Great Ouse* are forced down the New *Bedford* river, so improperly situated for that purpose.

There is one thing which I plainly foresee, and that is, if the tides are admitted into the Old *Bedford* river, and the waters of the *Ouse* turned down it as before proposed, in the time of *land floods*, the descent of the waters through

Salter's lode sluice, would be interrupted, in the same manner as the waters of the south level were interrupted in passing through *Denver sluice*, by the descent of the land floods through the *New Bedford river*.

To remedy this, I would propose that the *Tong's drain* should be enlarged, deepened, and substantially imbanked, and *Popbam's Eau* the same; and the waters of the *Nene*, which now come through *Salter's lode sluice*, should be carried off by those two drains; pen sluices should be fixed at the ends of *Tong's drain*. for the use of navigation through it; and one sluice should be set at *Well Creek's End*, at *North Delph*, and another in the river *Nene*, a little below the upper end of *Popbam's Eau*, to keep up an head of water for the use of navigation, through *Well Towns*. If the river was properly deepened up to *Standground sluice*, and that part of the *Nene* from *Peterborough* to *Wisbeach*, was properly imbanked and deepened, so as to lower the stagnant freshes now dammed up at *Peterborough*, six or eight feet, all which I consider as *primary* works, then I do conclude, that both the *middle* and *south levels* would receive if not the *utmost* relief, yet such improvement as would render them fit for cultivation, secure them from the annoyance of the waters, and make them a fruitful and flourishing country.

Which, without any interest in the event for the honour of the nation, and the good of the community, I should rejoice to see.

F I N I S.

